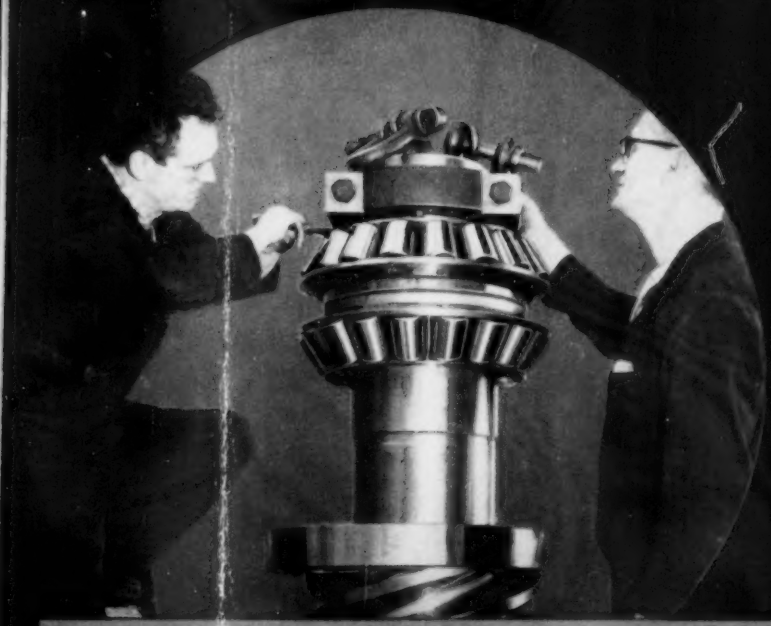
Sheet Metal Industries

The only Journal in the World wholly devoted to the Manufacture, Manipulation, Fabrication, Welding, Assembly and Finishing of Ferrous and Non-Ferrous Sheet and Strip

VOL. 37 : No. 402 OCTOBER 1960 PRICE 2/6



Taking heavy end-thrust

Fitting a two-row Timken steep-angle bearing on the screw-down gear of a new 144-inch 4-high mill.

British Timken, Duston, Northampton, Division of The Timken Roller Bearing Company. Timken bearings manufactured in England, Australia, Brazil, Canada, France and U.S.A.

Photo by courtesy of Davy and United Engineering Company Limited.

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tapered roller bearings

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IMPROVED STANDARD OF LIVING

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First in Europe to install a continuous wide-strip mill, RTB make steel that serves you in many ways.

For without RTB modern methods and strip-mills, many amenities, nowadays taken for granted, might have been unknown at a reasonable price: your stainless steel sink, your motor body, those thousands of household articles.

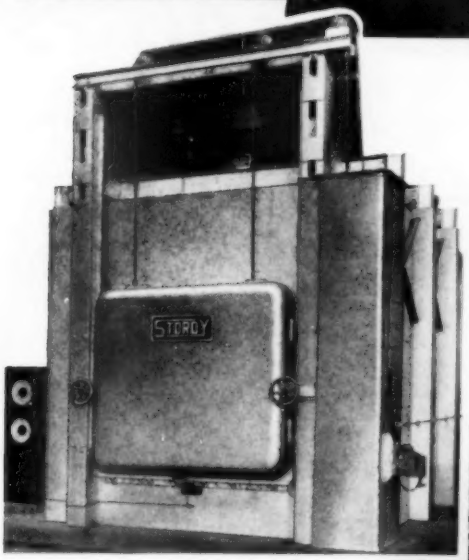
The artist's impression shows a forged motor-car stub axle, a stainless steel sink, blue planished sheet and some galvanized sheets against a coil of cold-reduced steel strip, all made by RTB or from RTB steel.

Richard Thomas & Baldwins Ltd.

R·T·B

STORDY

HEAT TREATMENT FURNACES



The range of Stordy heat treatment furnaces include batch, pit and continuous types, heated by oil, gas or electricity, with indirect firing when required. The Stordy system of forced air circulation is unique in its efficiency and in providing rapid heating up rates and uniform heating conditions throughout the chamber with maximum fuel economy. Stordy heat treatment plant includes all the necessary materials handling equipment—robust charging and discharging machines, conveyors, transfer tables, loading and unloading racks.

Illustration above:
Electrically heated, air circulated batch-type furnace for aluminium. Working temperature 600° C., the furnace being complete with electric heater batteries and circulating fans, designed for ease of removal.

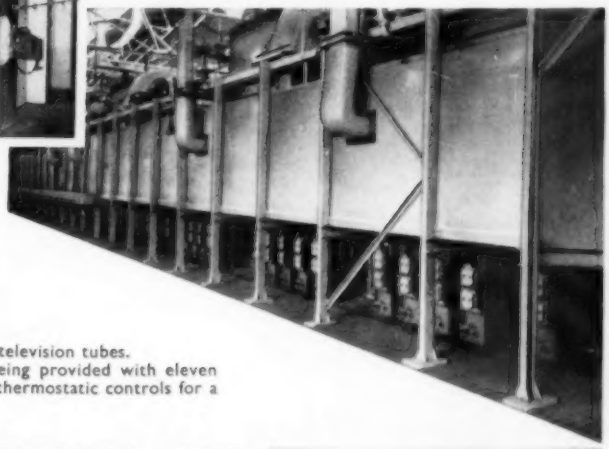
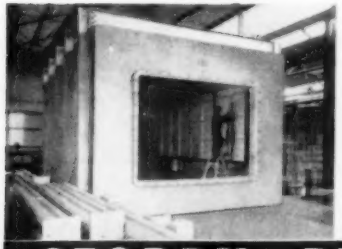


Illustration right:
High temperature heat treatment oven for television tubes. The oven has a heated length of 206 ft. being provided with eleven combustion chambers, circulating fans and thermostatic controls for a maximum temperature of 450° C.



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Editorial Contents. page 715 **Classified Advertisement pages. 121**

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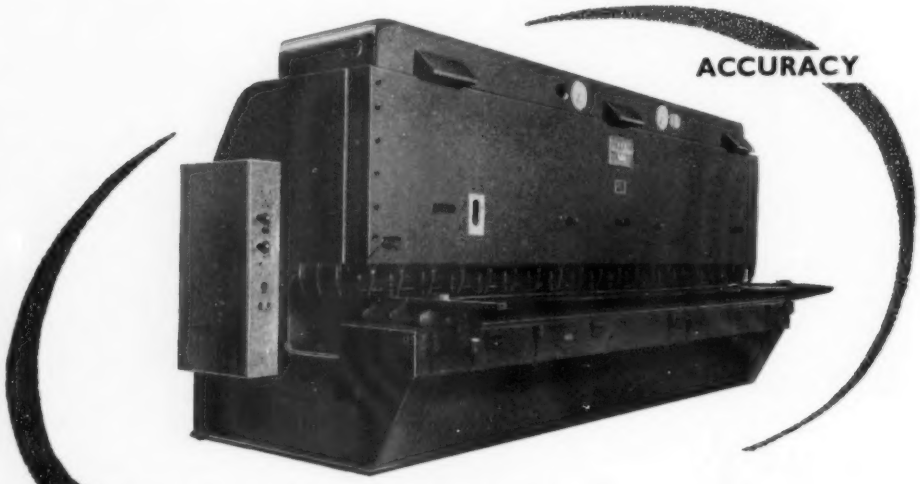

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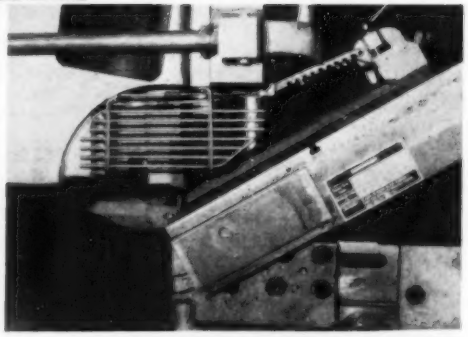

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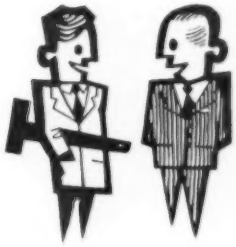

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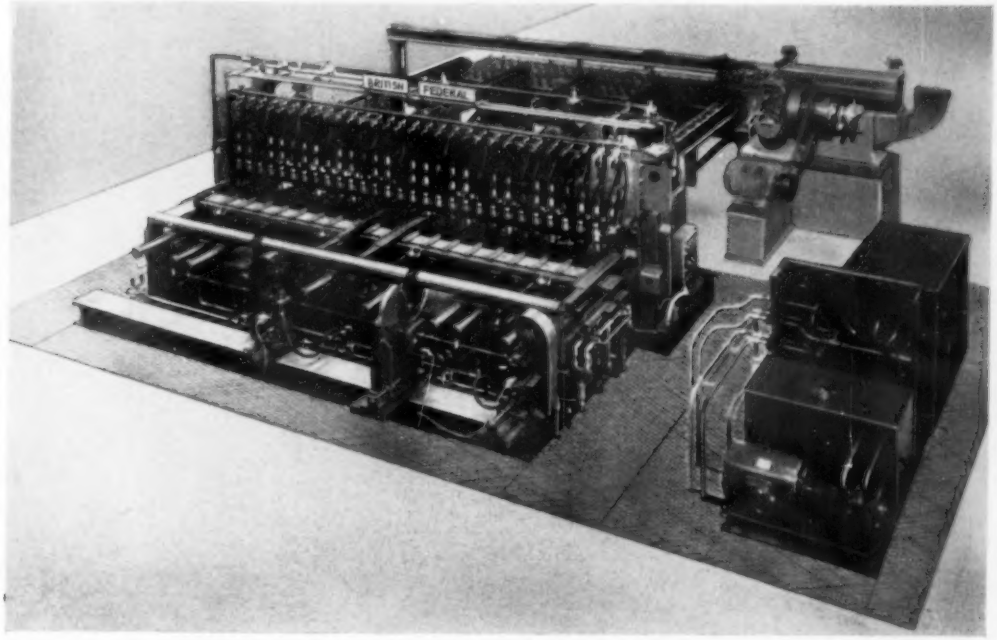

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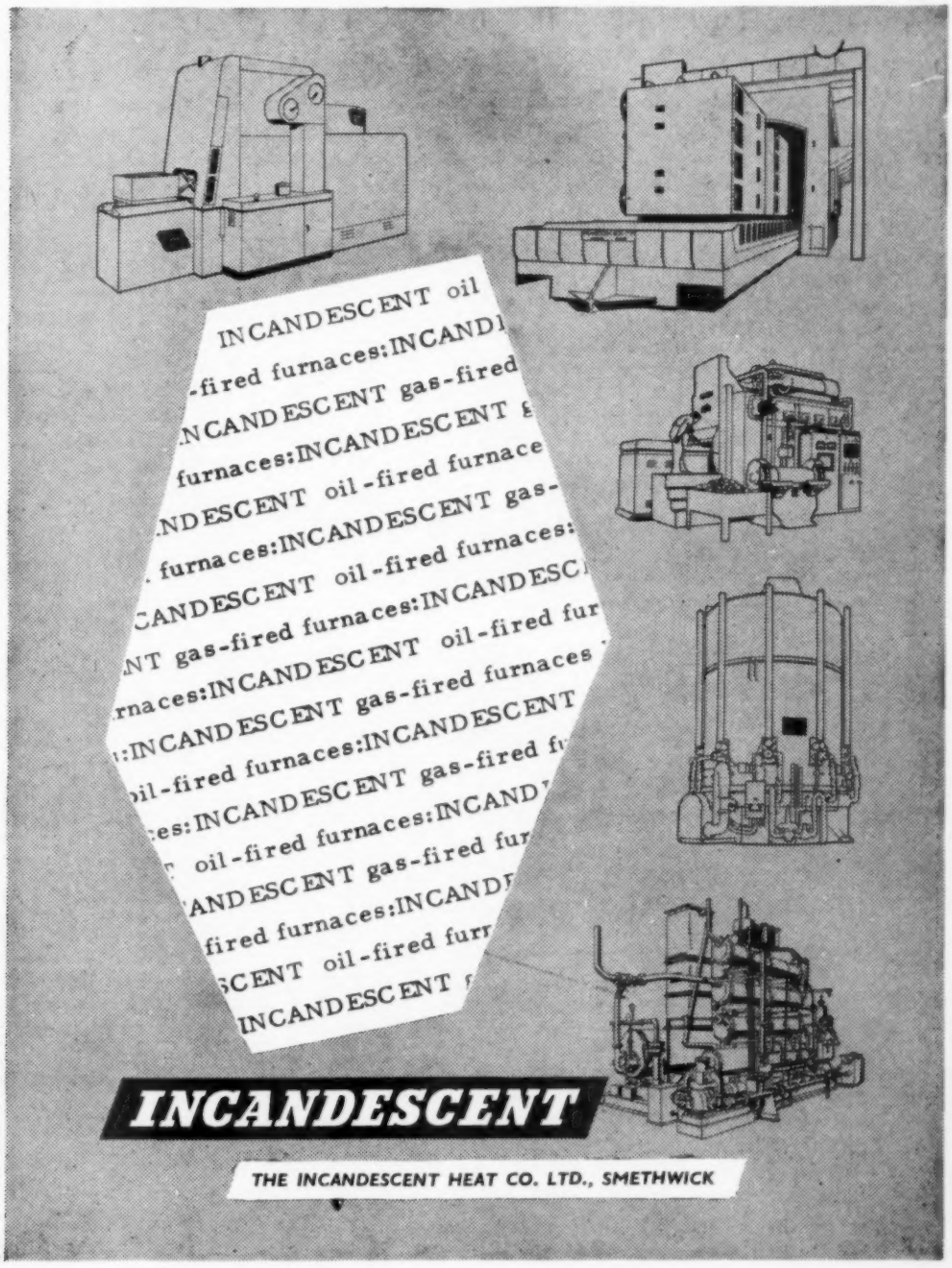
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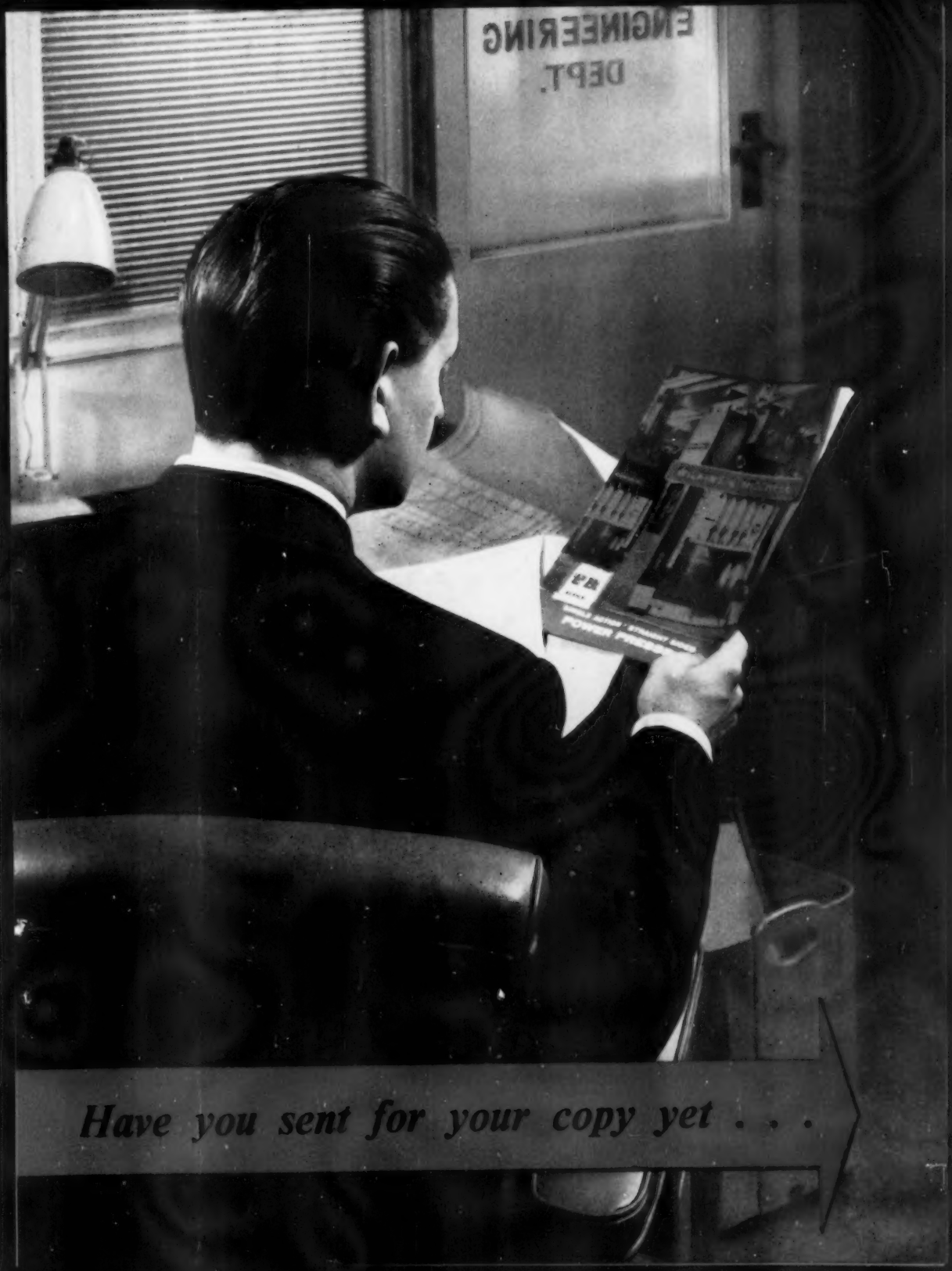
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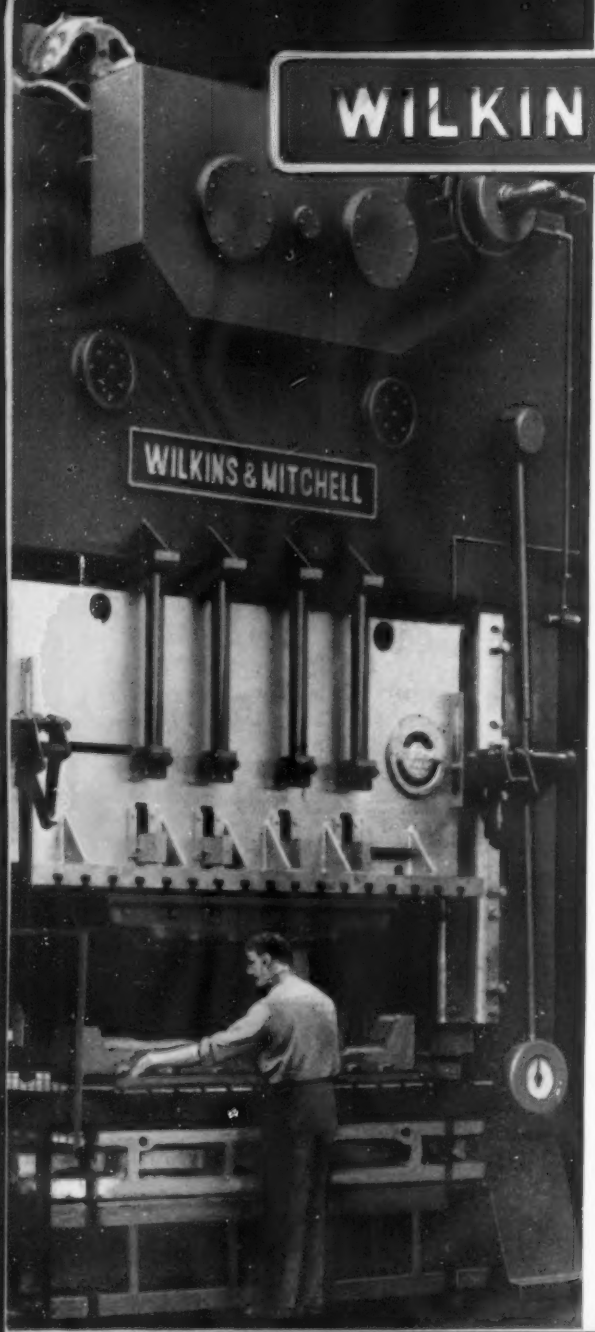

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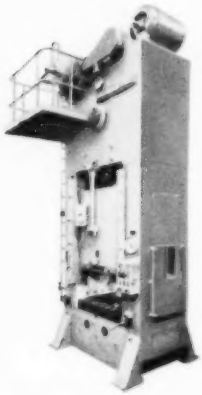
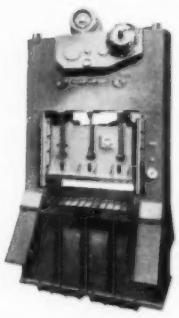


These many features, essential for greater productivity are embodied in this range of Wilkins & Mitchell Power Presses —the presses that cut costs . . .



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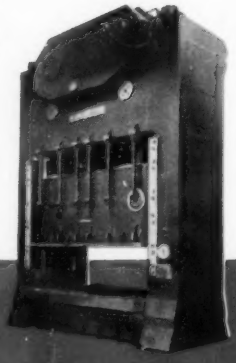

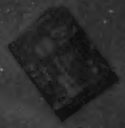

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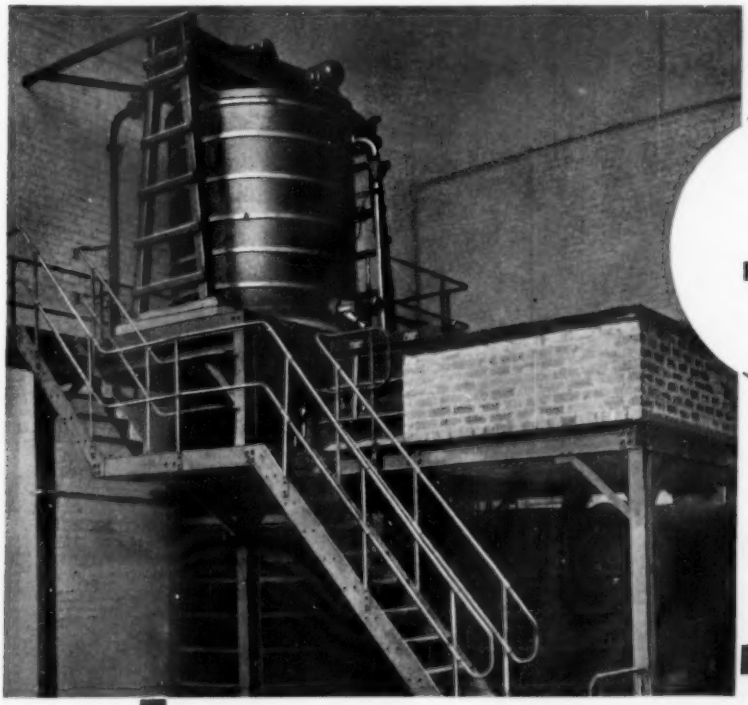

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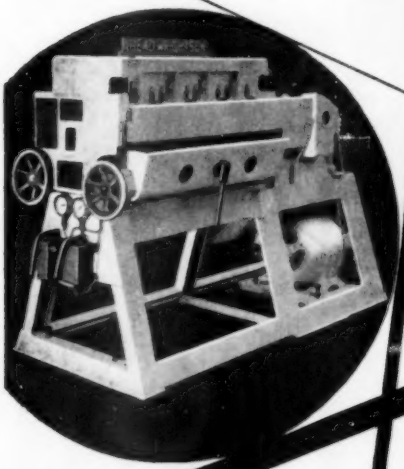
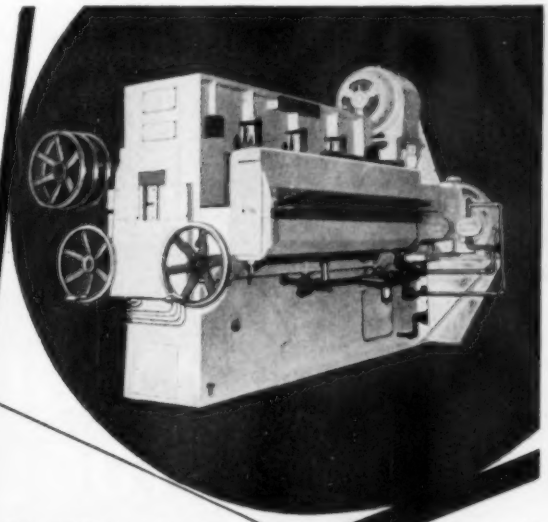
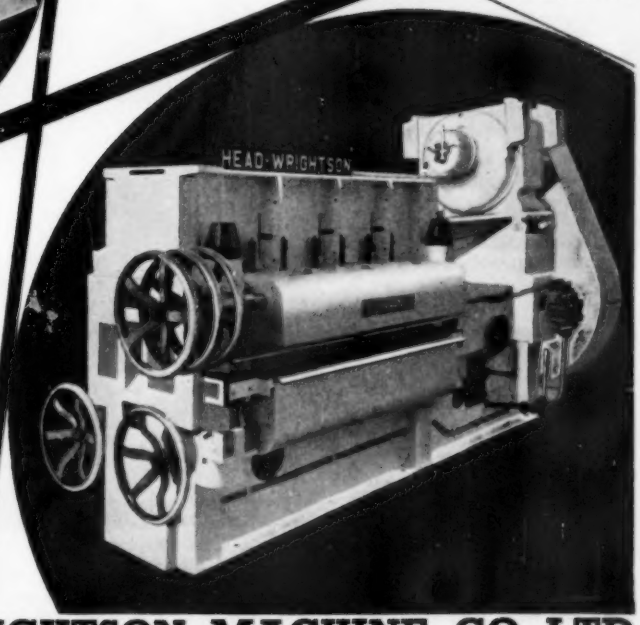




Top: 1¾" Processor Leveller

Bottom: 2½" Pressure Regulating Roller Leveller



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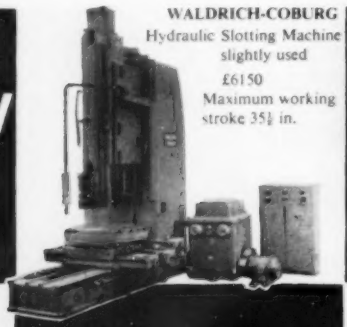

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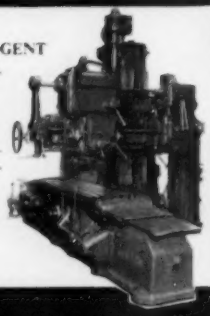

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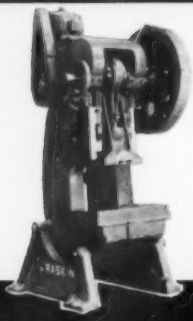

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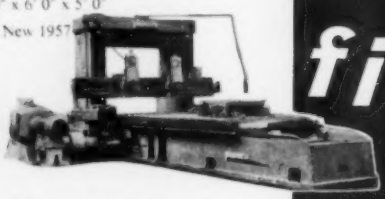

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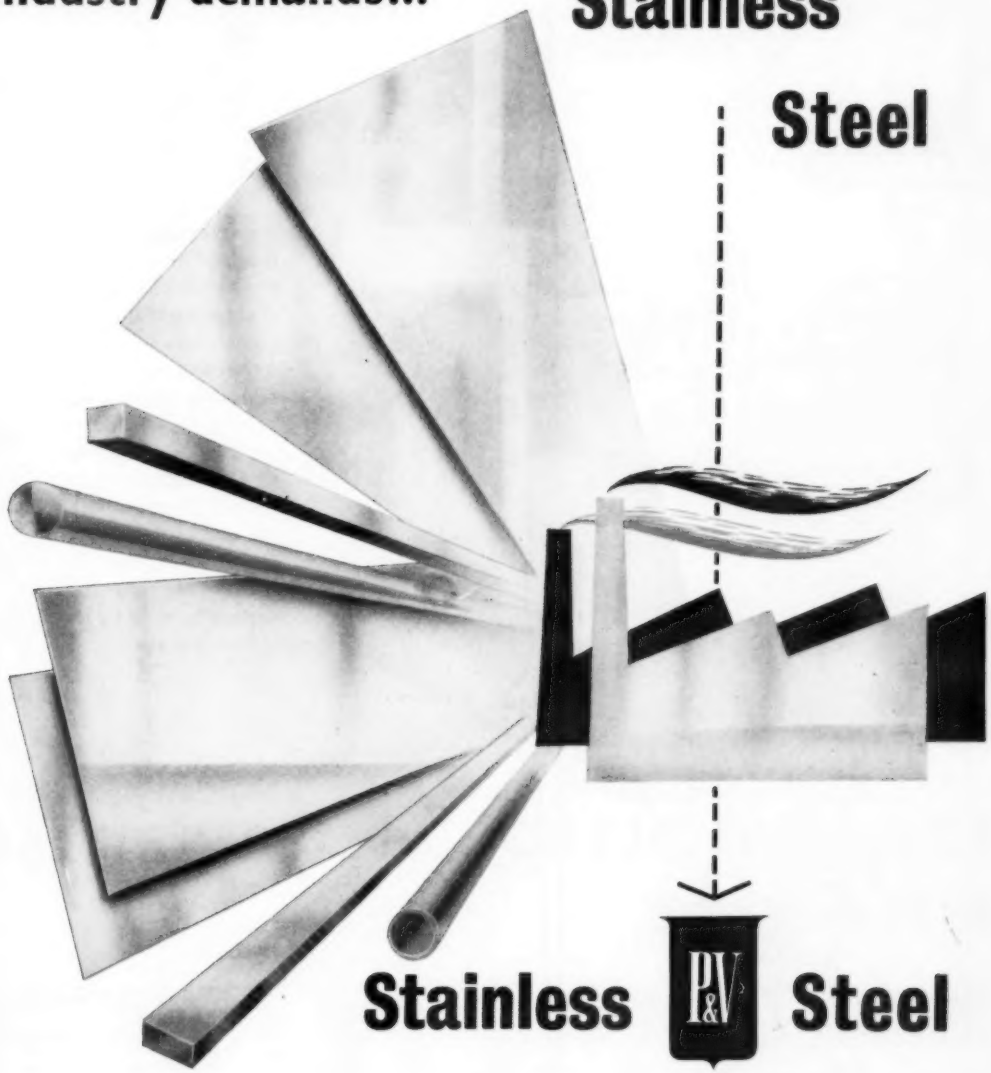

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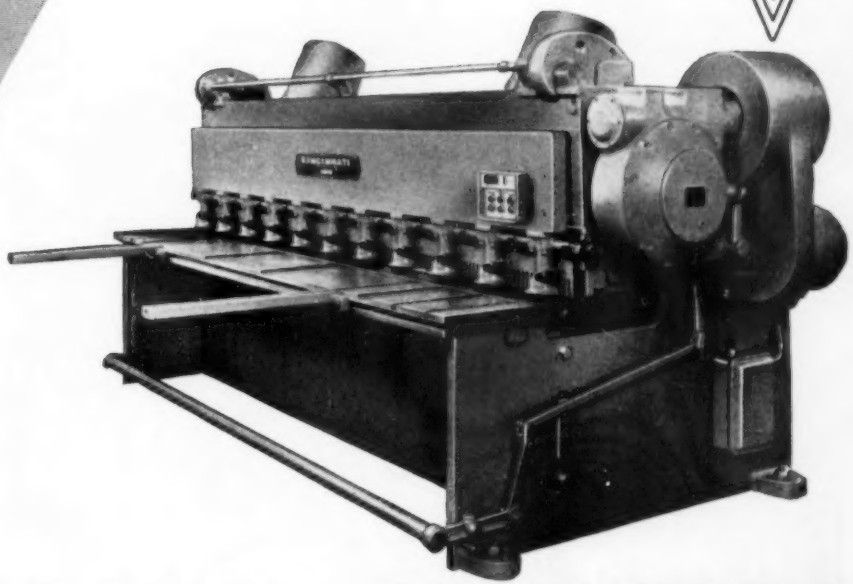

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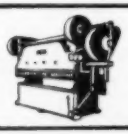

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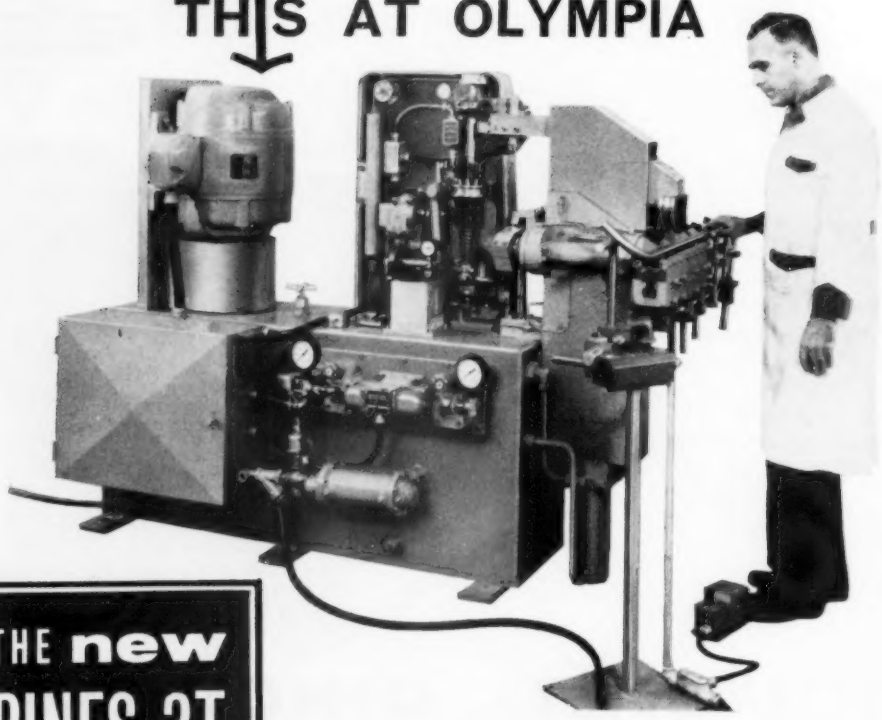

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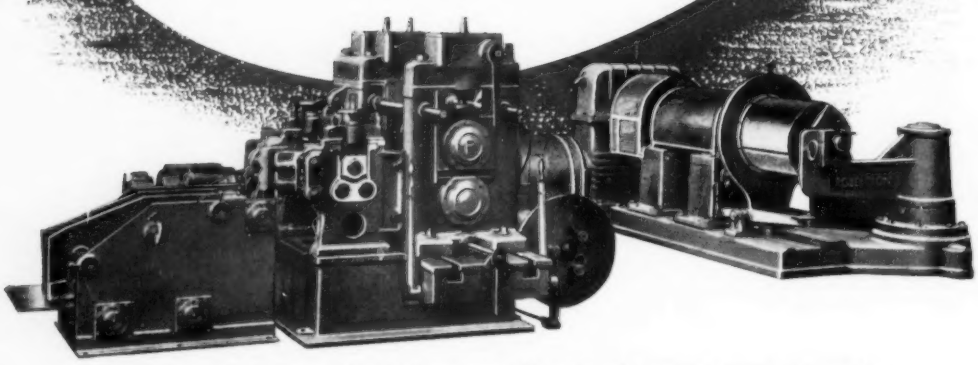

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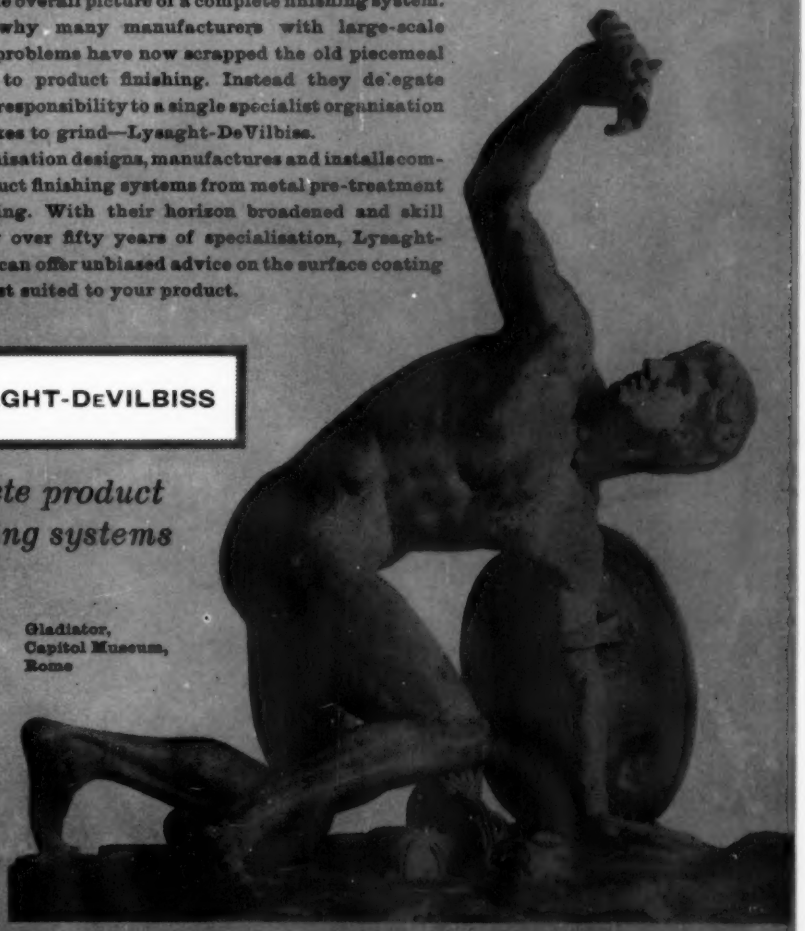

Gladiator, Capitol Museum, Rome

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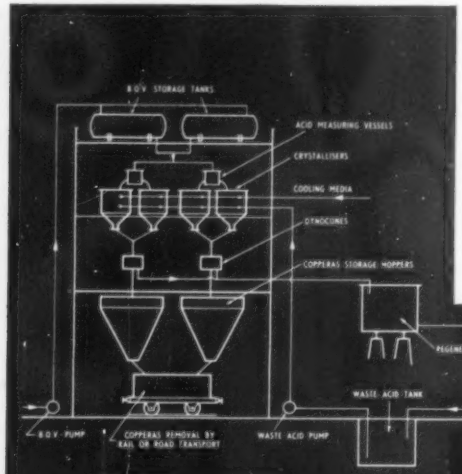


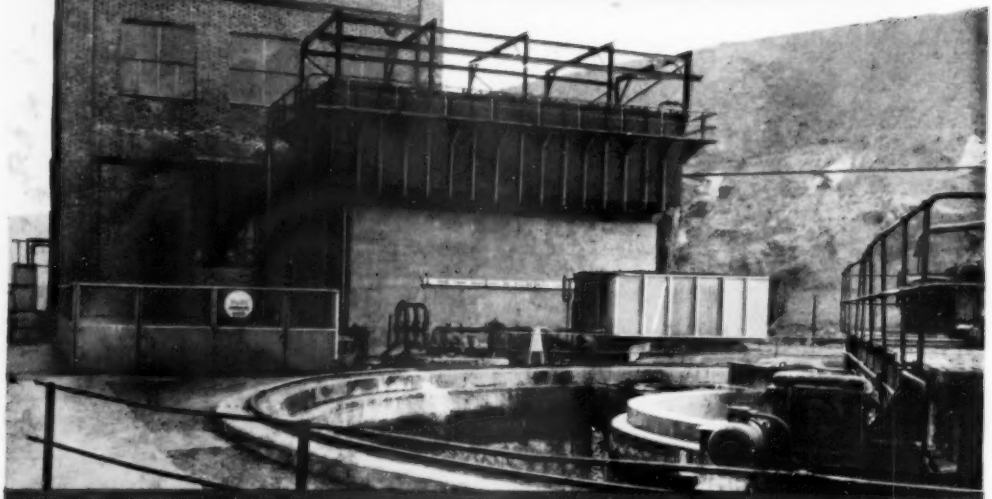
ACID RECOVERY PLANT FLOW DIAGRAM

The sulphuric acid regeneration plant recently installed by John Thompson (Dudley) Ltd., at the new Brinsworth Mill of Steel, Peech & Tozer, is probably the largest of its kind in this country. The complete plant is capable of treating all spent pickle liquors from the continuous strip lines in the mill, and provision has been made for doubling the capacity of this plant at a future date to meet the demand when the mill is working at maximum capacity.

In addition to the above there is installed a large neutralisation plant for dealing with all waste effluents from the continuous strip lines. These plants are larger than any likely to be required in the wire industry, but the same principles are applicable to plants on a smaller scale and of smaller capacity, which would be of considerable interest and value to the medium and large wire mill using sulphuric acid.

JOHN THOMPSON (DUDLEY) LIMITED
JOHN THOMPSON GROUP

Treatment of Waste Acid and Effluent from Continuous Strip Pickling Lines



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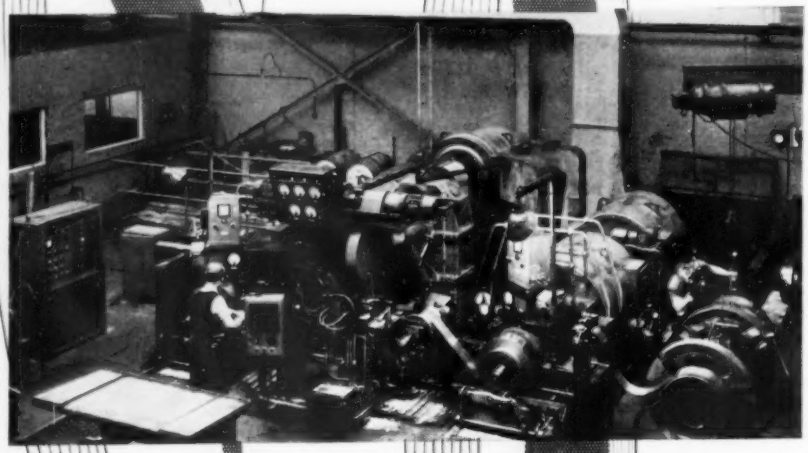

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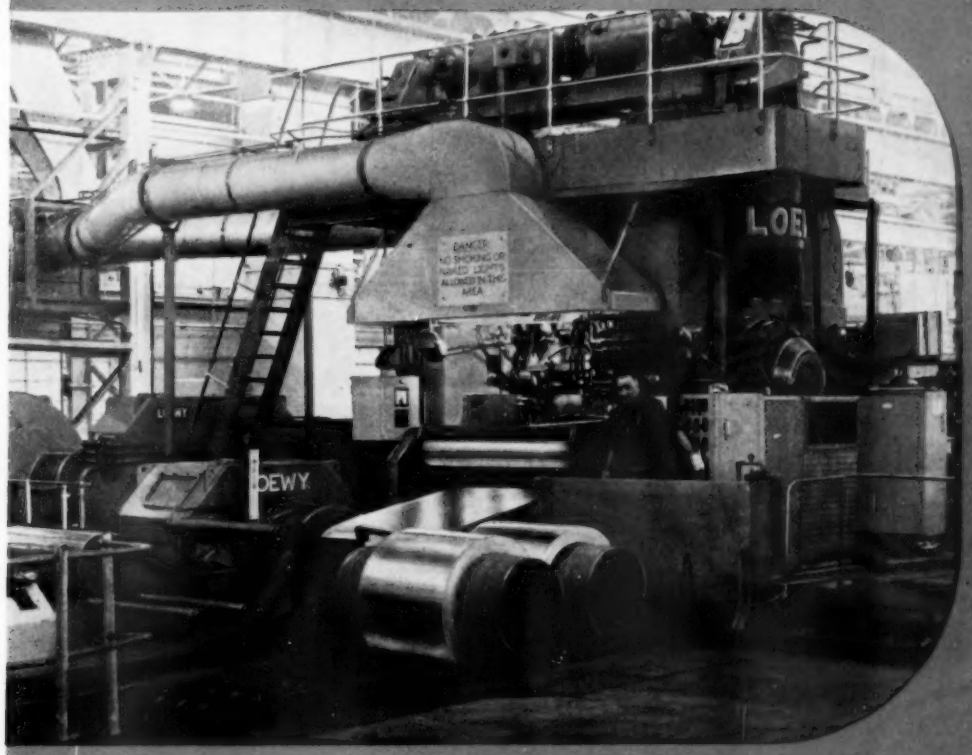

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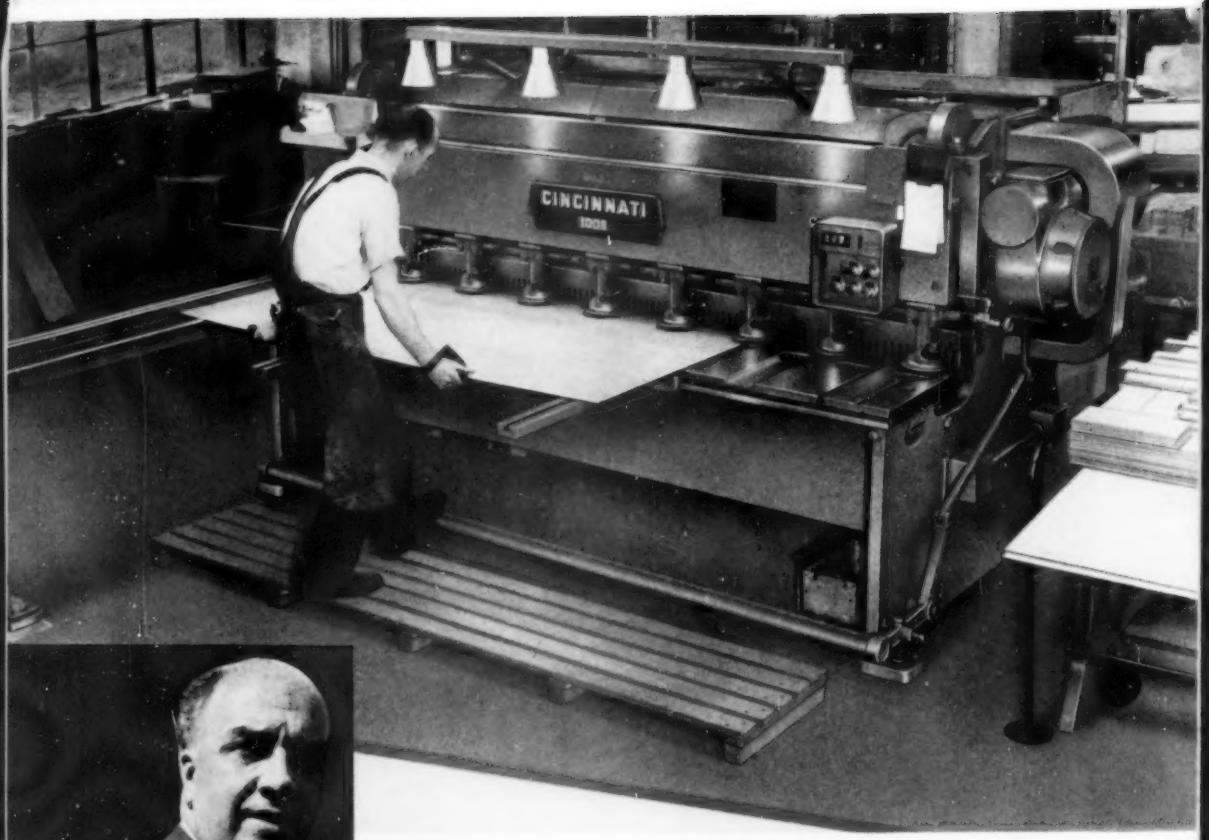

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says Mr. Sam Craig, Works Manager of the Belmos Company Limited, Blantyre

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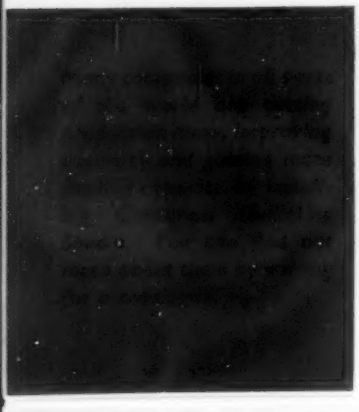

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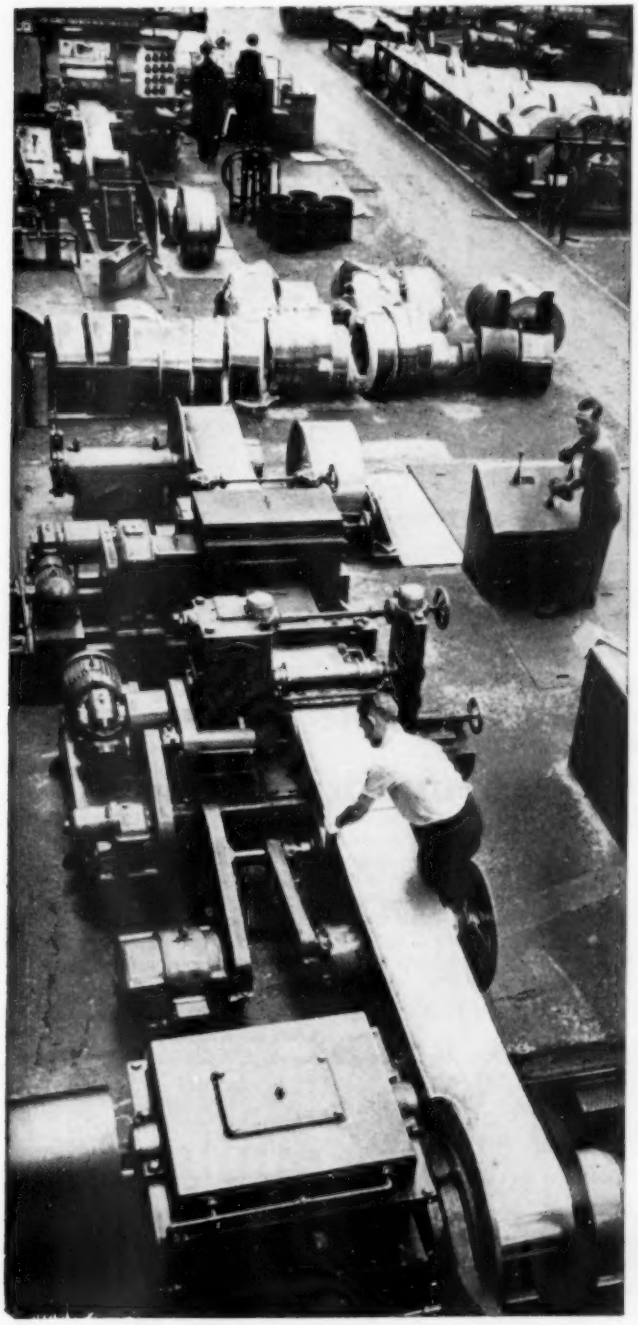

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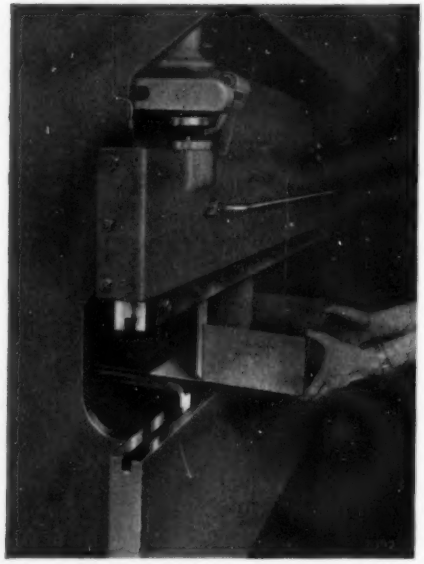

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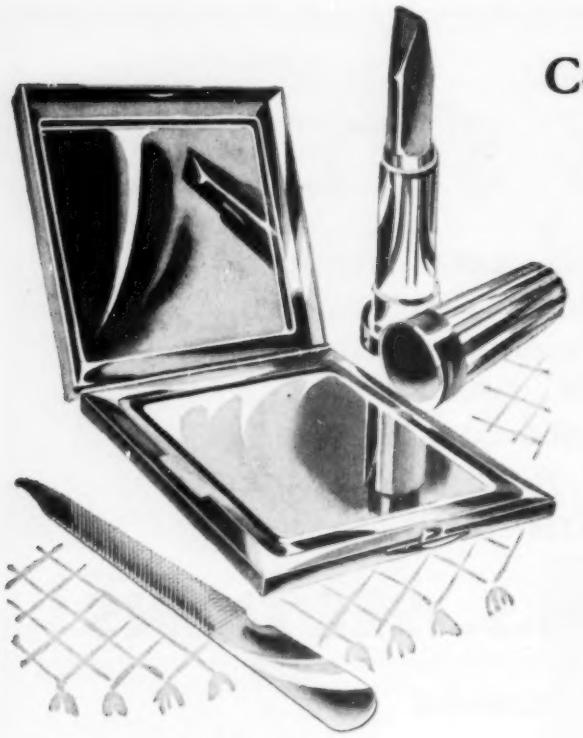

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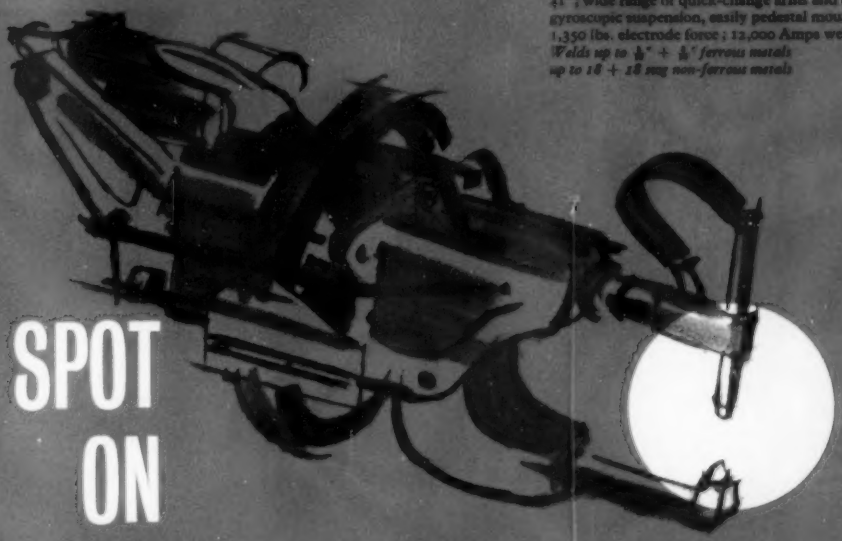

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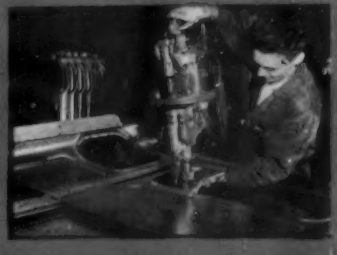

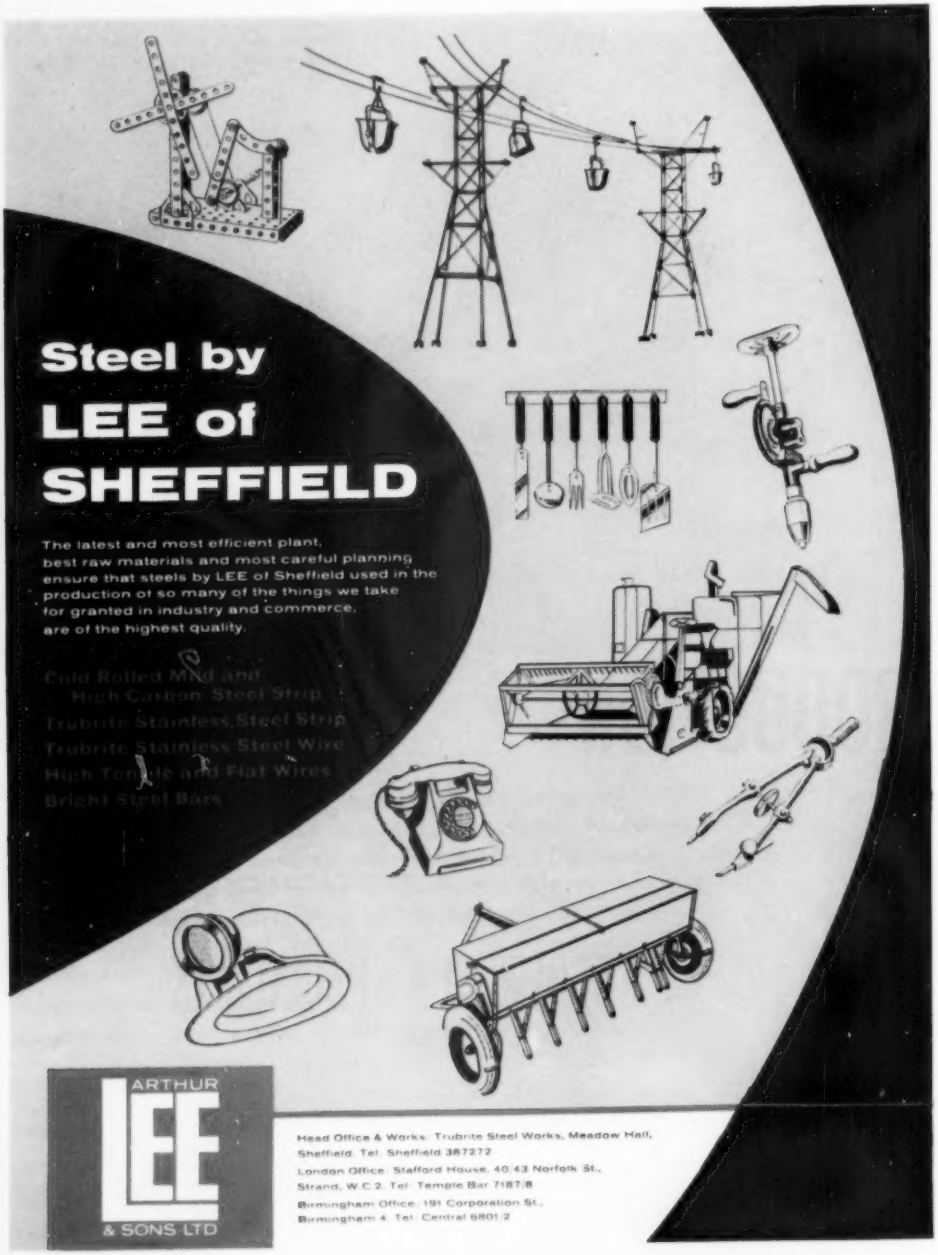
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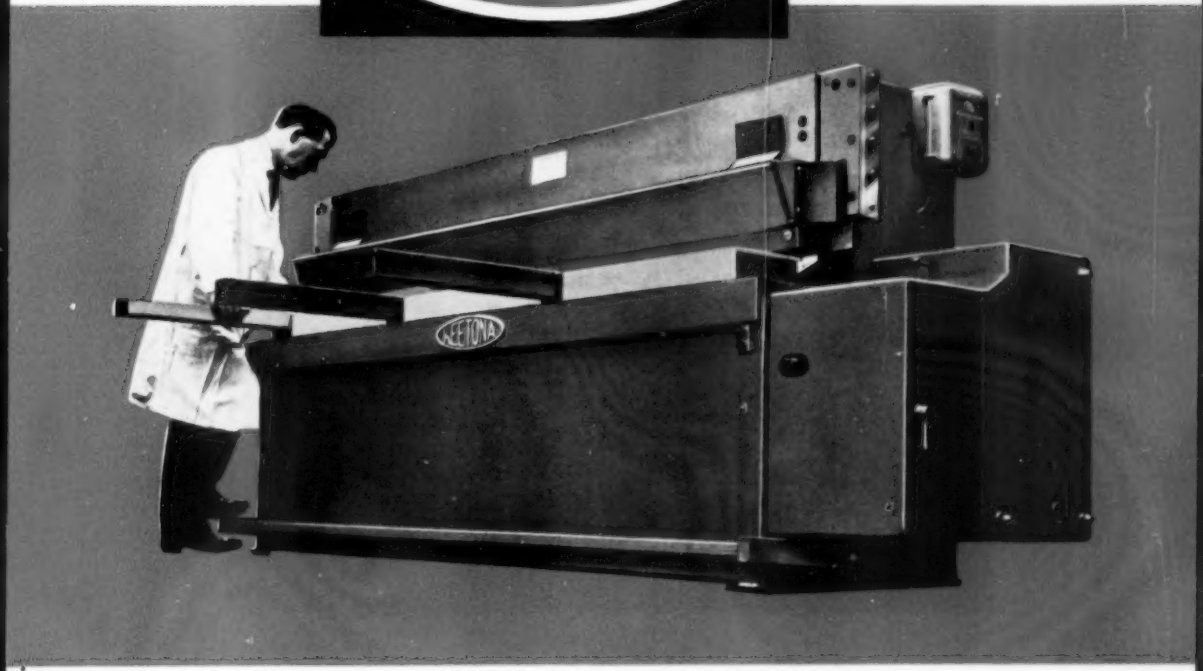

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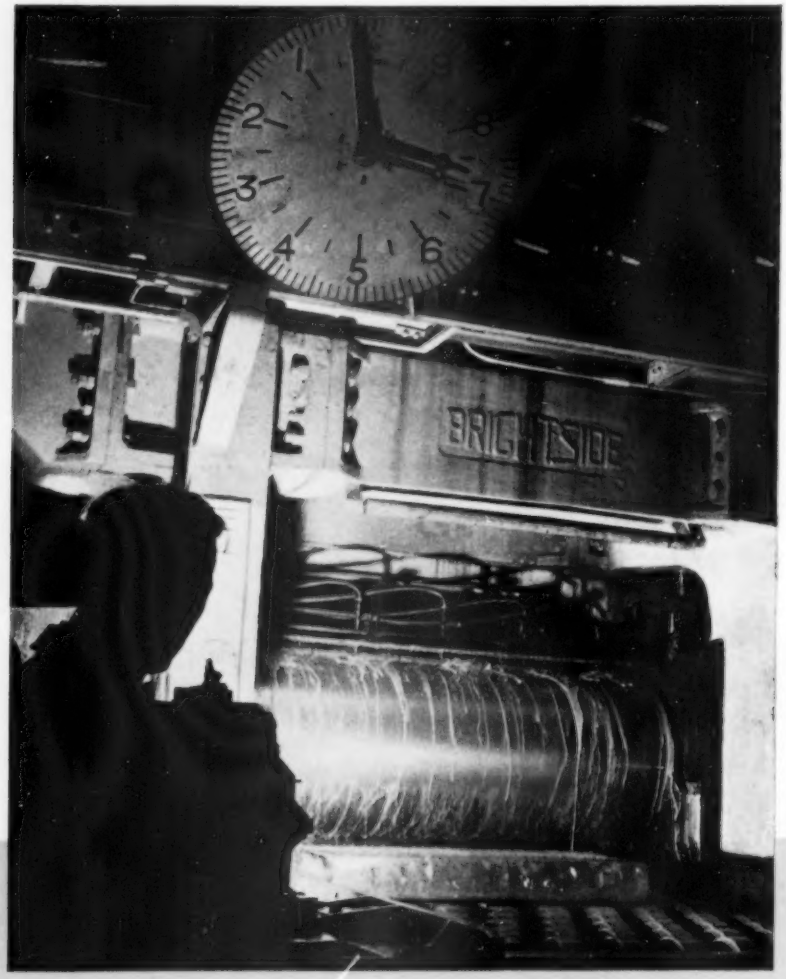

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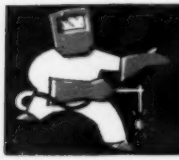

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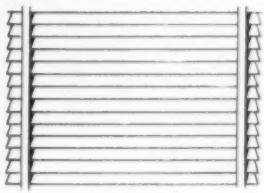

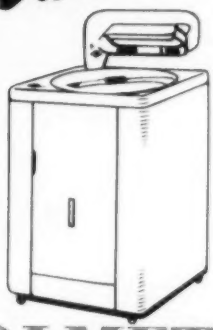

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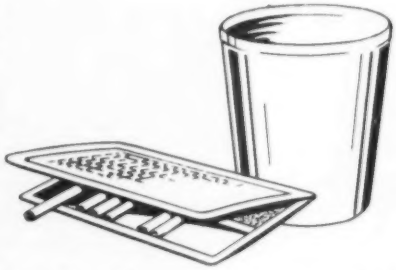

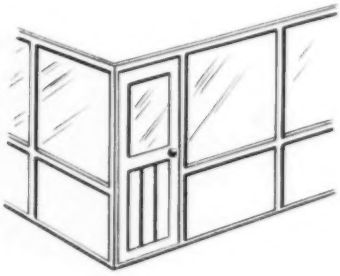

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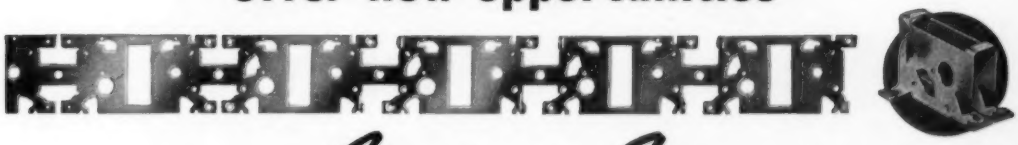

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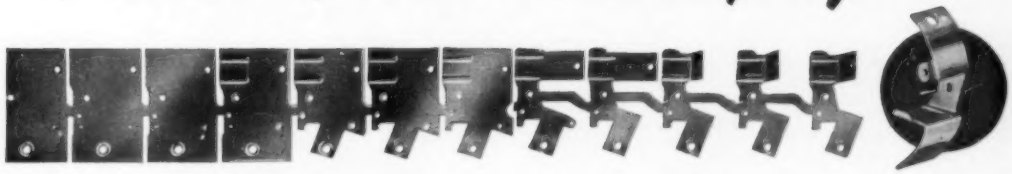

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US 5

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Immediately a sheet is fed into the machine, the Flexing Roll automatically moves from its idle position into its upper working position, causing the sheet to make two quarter-turns and one reverse half-turn before travelling into the backed-up levelling rolls, where it is repeatedly flexed and finally ejected as a flat sheet. This process kneads the steel and imparts to it the desired amount of cold plasticity.

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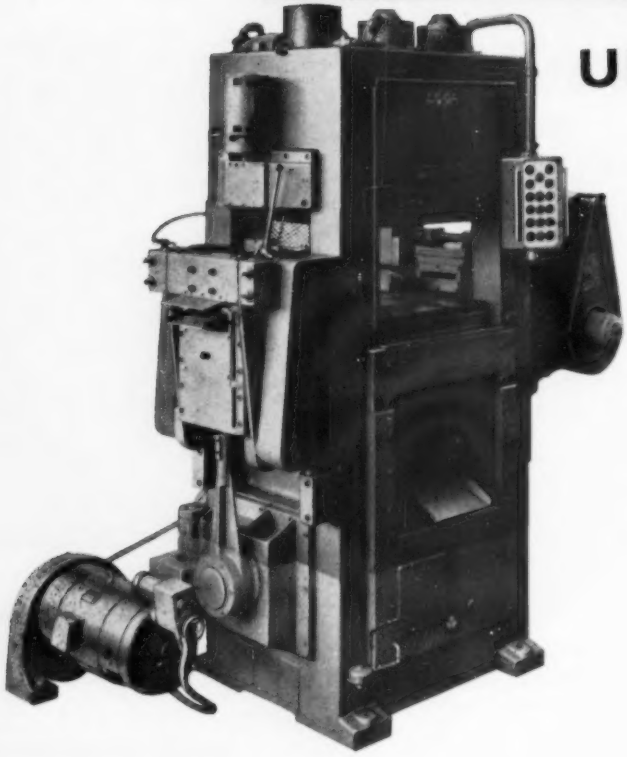

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GIVE 7 TO 10 TIMES NORMAL TOOL LIFE—

PLUS GREATLY INCREASED PRODUCTION RATES ! ! !

This precise and rugged Swiss-built machine gives greatly extended tool life up to, invariably, seven to ten times that obtained from any other type of Press by virtue of its design whereby vertical backlash is entirely eliminated; this means that the punches can be set so that they never enter the die. The machine shown is a double crank type equipped with double roll feed, strip end shear, scrap shear, and automatic stopping device. There is a full range available from 6 to 240 tons, single and double eccentric.

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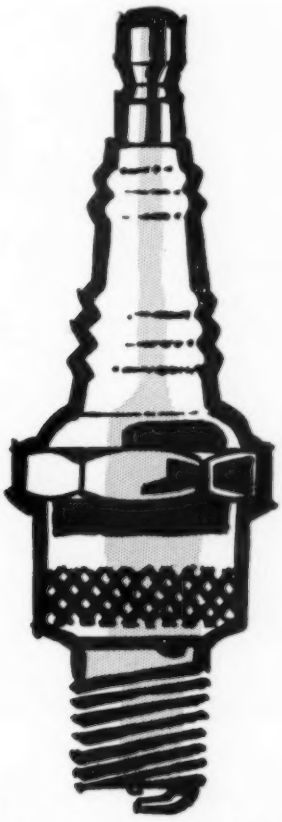

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Yet another Desoutter power tool for speeding assembly in the motor industry. This multiple tool inserts and tightens six sparking plugs, simultaneously, within 6 seconds. It uses six separate pneumatic motors which are designed to stall independently as soon as the desired torque is obtained.

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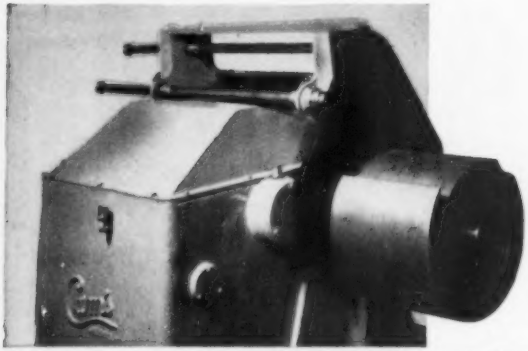

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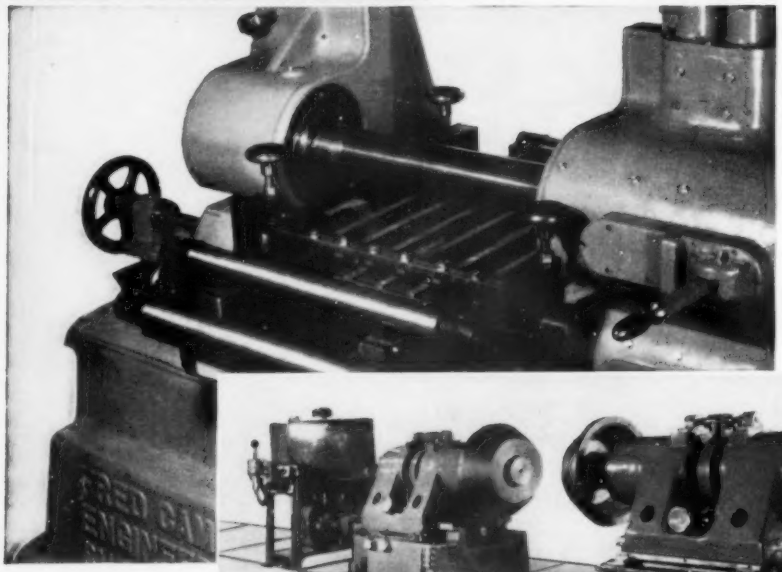

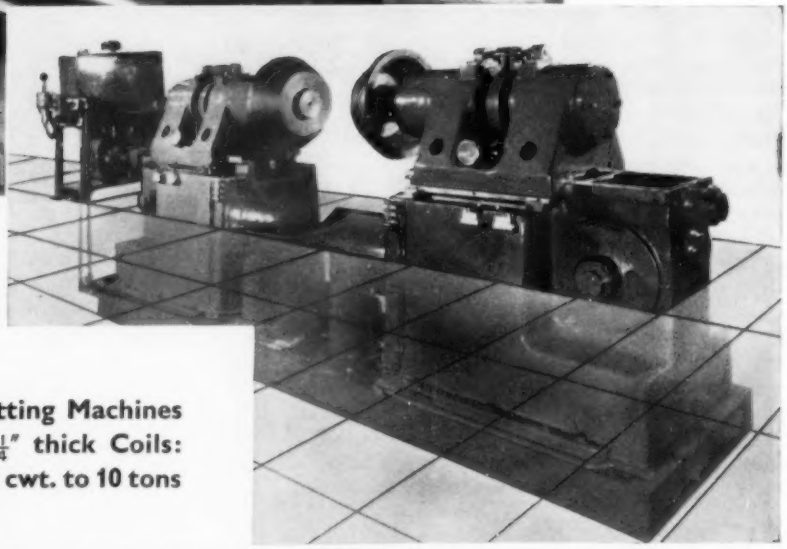

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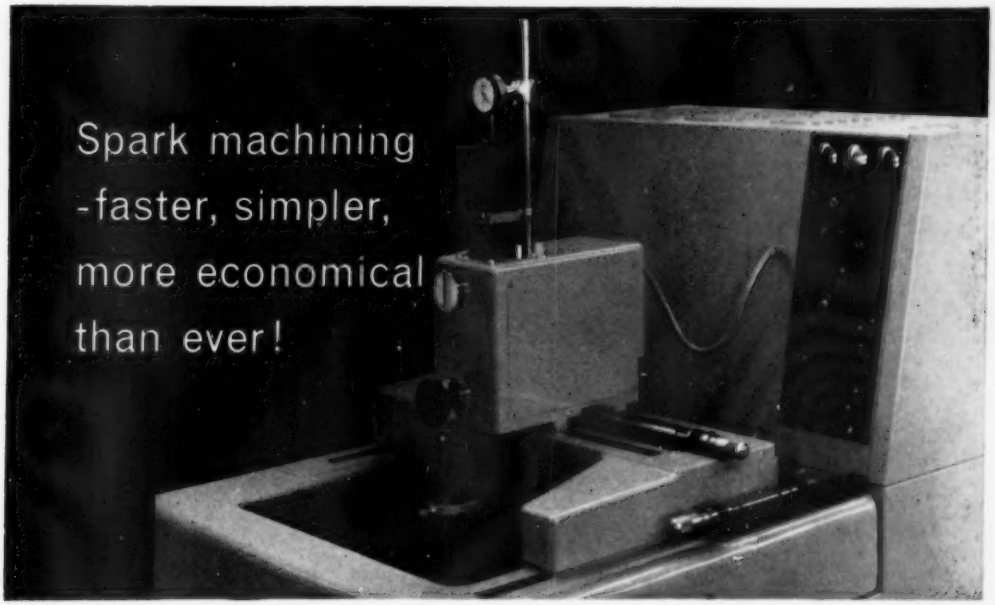

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The GKN Spark Machine (Models B1 and B2) gives higher cutting rates, greater accuracy, and—on the B2 machine—a wider range of surface finishes than ever before.

It has all these outstanding features

Both models have a co-ordinate slide movement for rapid electrode positioning; an accurate depth stop; a dial gauge to show forward movement; an alternative work-table for extra paraffin depth.

It is compact and economical

The GKN Spark Machine is well-made, sturdy and compact. All parts of it—work head, electrical equipment and paraffin system—are mounted in the same cabinet. Yet with all these advantages, installation and running costs are low.

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Whether you are engaged in forging, wire-drawing or press-tool making, the GKN Spark Machine is something you should know about. Write to our Sales Agents for the new brochure on:—

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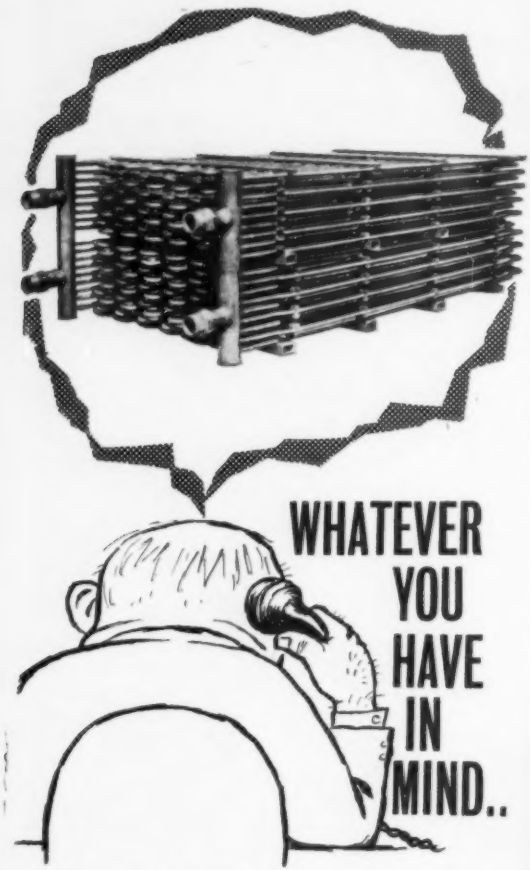

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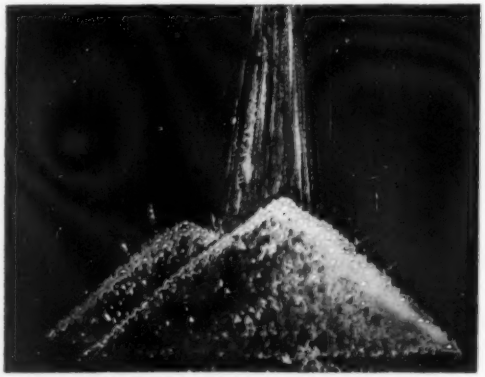

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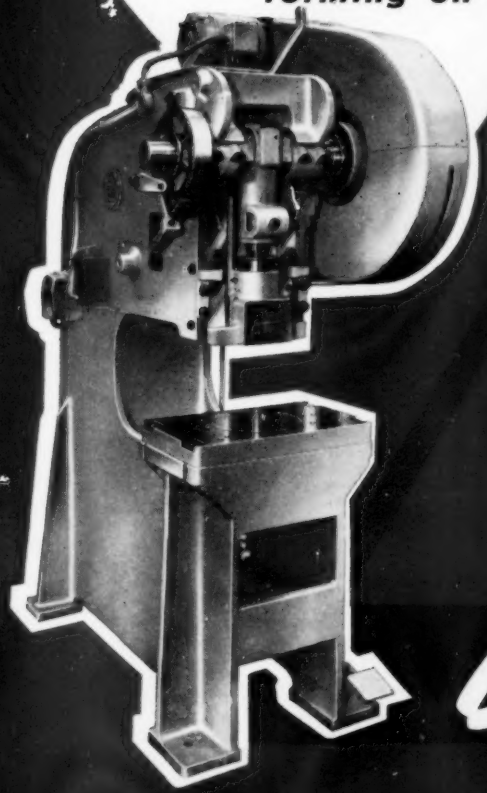

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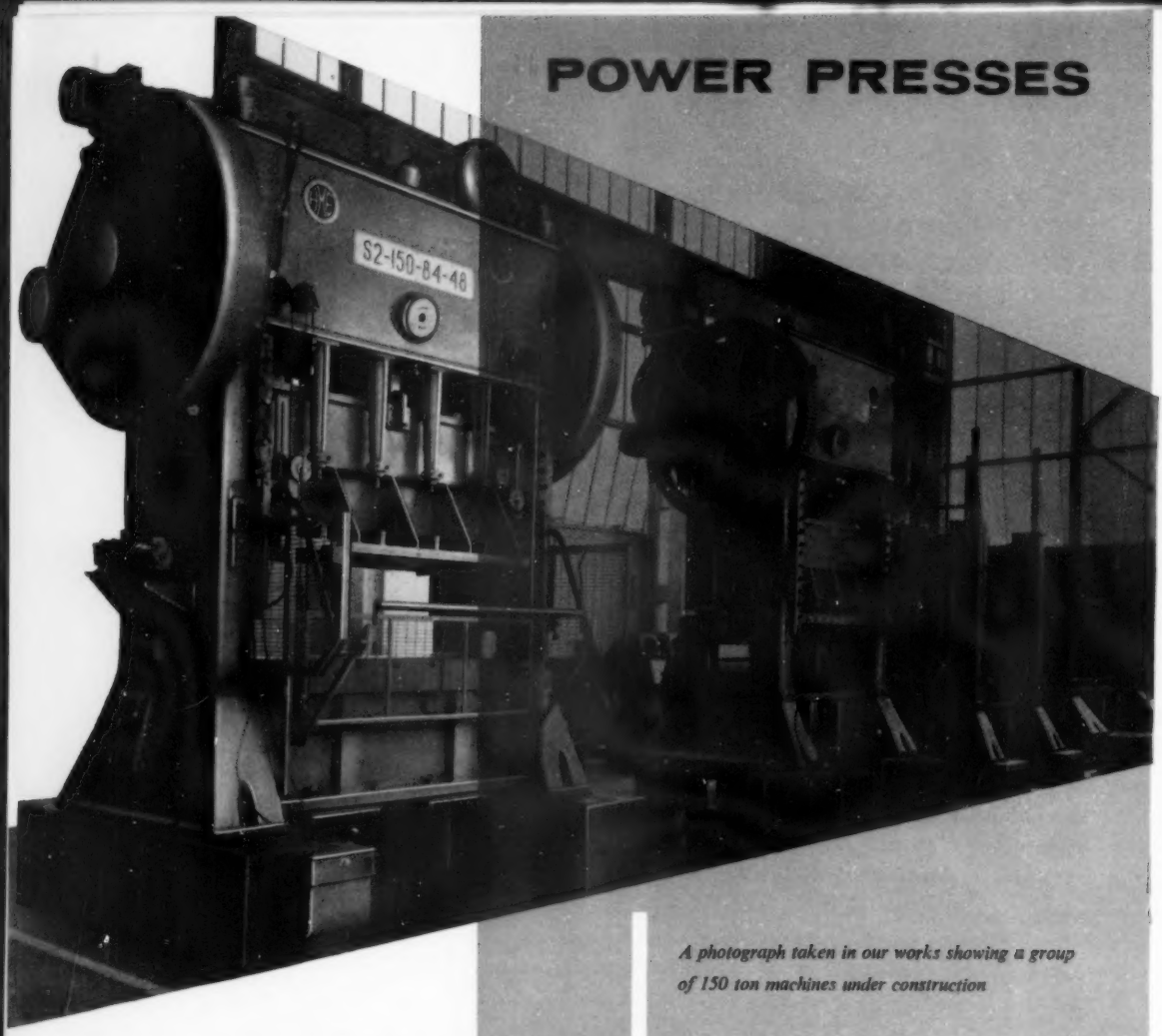

A photograph taken in our works showing a group of 150 ton machines under construction

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The construction of presses in the larger range has become a production line affair. Send for details of the features of these machines or, should you prefer, we will be pleased to arrange for one of our specialist engineers to call.

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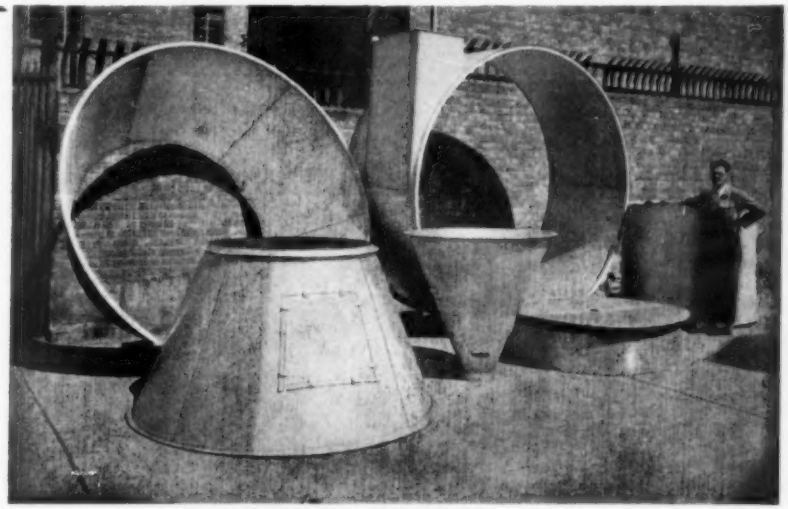

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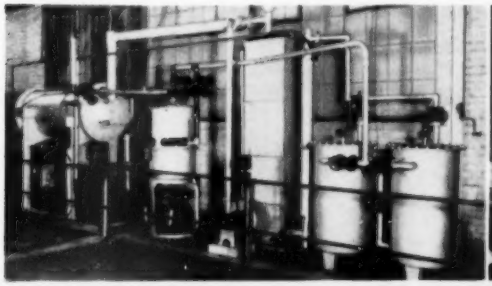

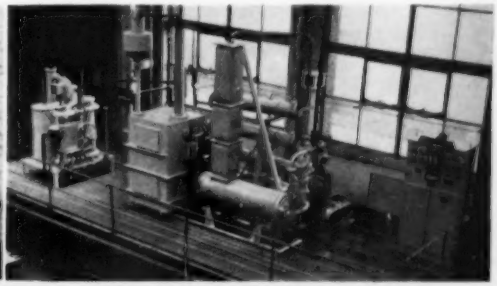

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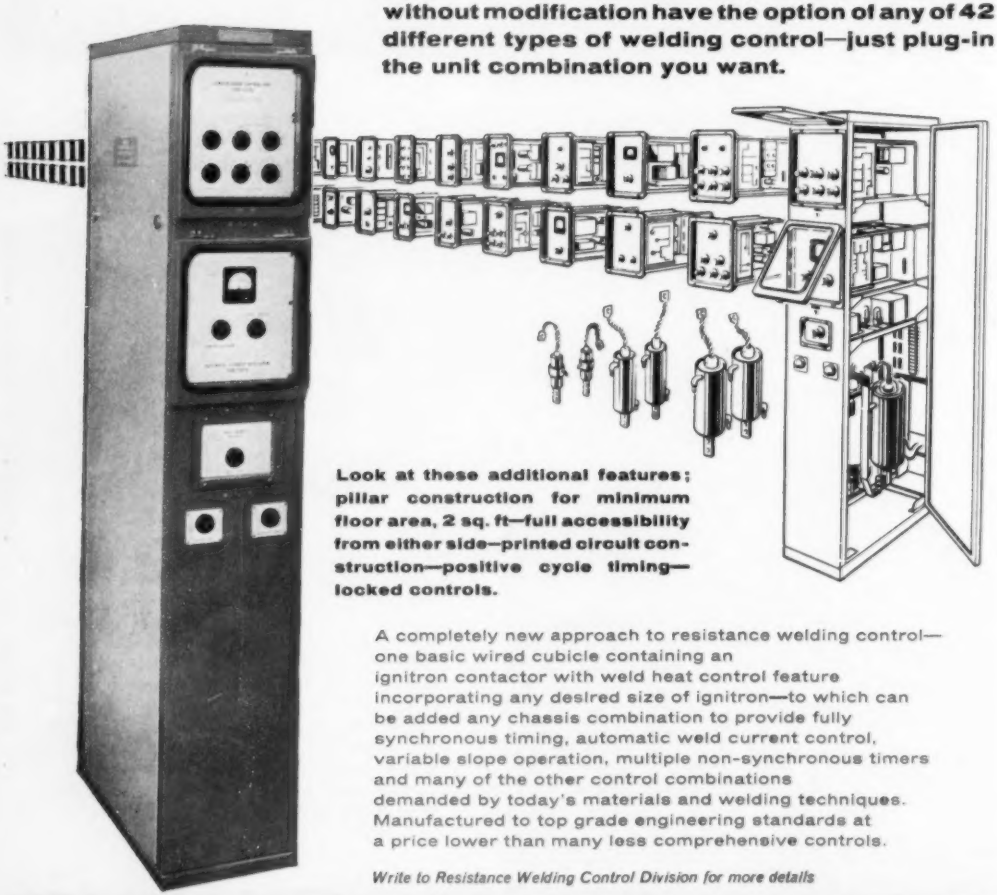

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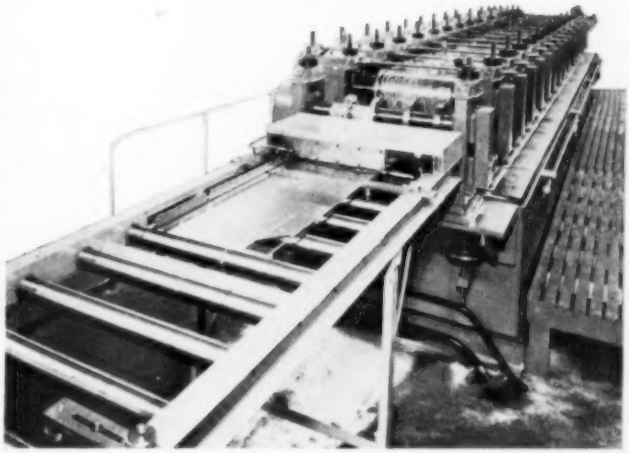

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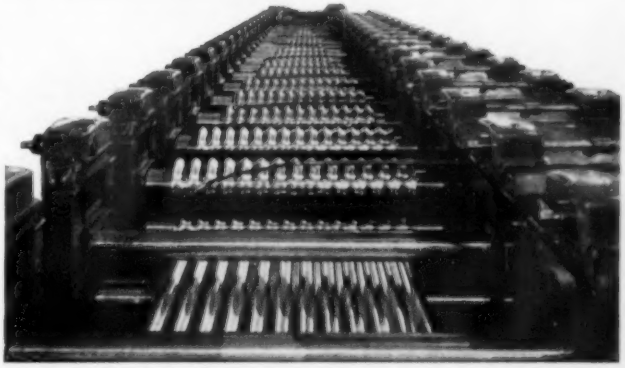

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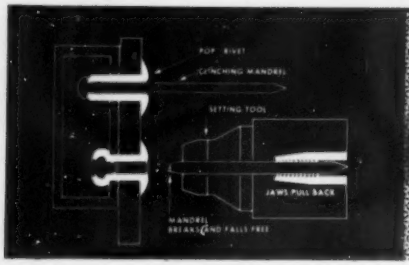

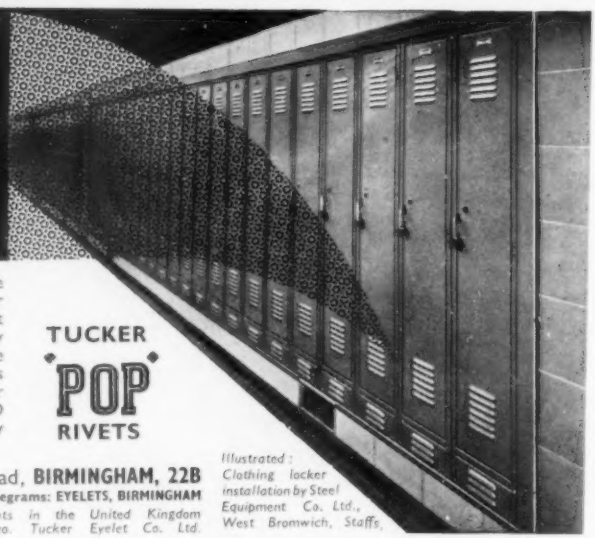

Almost unlimited in its field of application, the 'Pop' Riveting System is being used for an ever widening range of assembly operations in the sheet metal industry. Requiring only one operation by one operator, working from one side of the material only, to set or clench the rivet, it enables rivets to be set in positions inaccessible by other methods. THIS COULD BE THE ANSWER TO YOUR ASSEMBLY PROBLEMS. We will gladly send you further details on request.

TUCKER 'POP' RIVETS

Illustrated: Clothing locker installation by Steel Equipment Co. Ltd., West Bromwich, Staffs.

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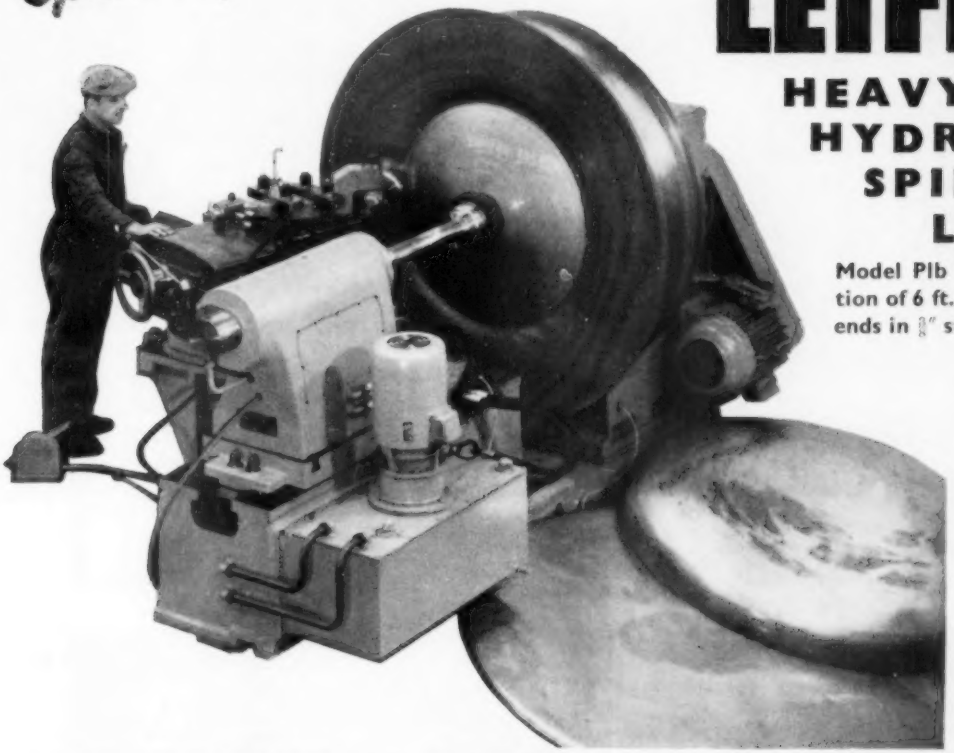

Model Plb 1200 on production of 6 ft. diameter dished ends in $\frac{3}{8}$" steel plate.

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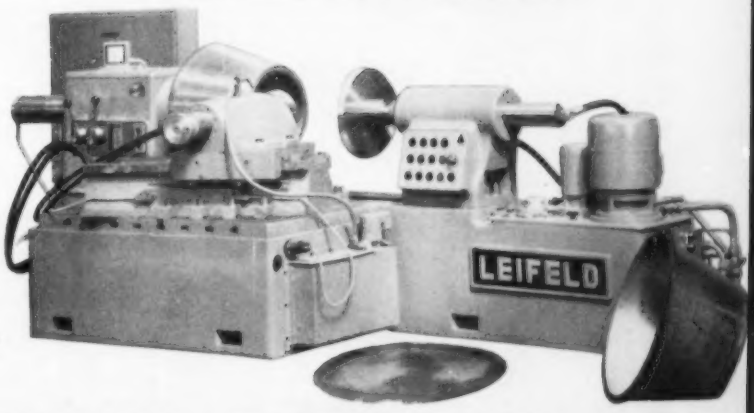

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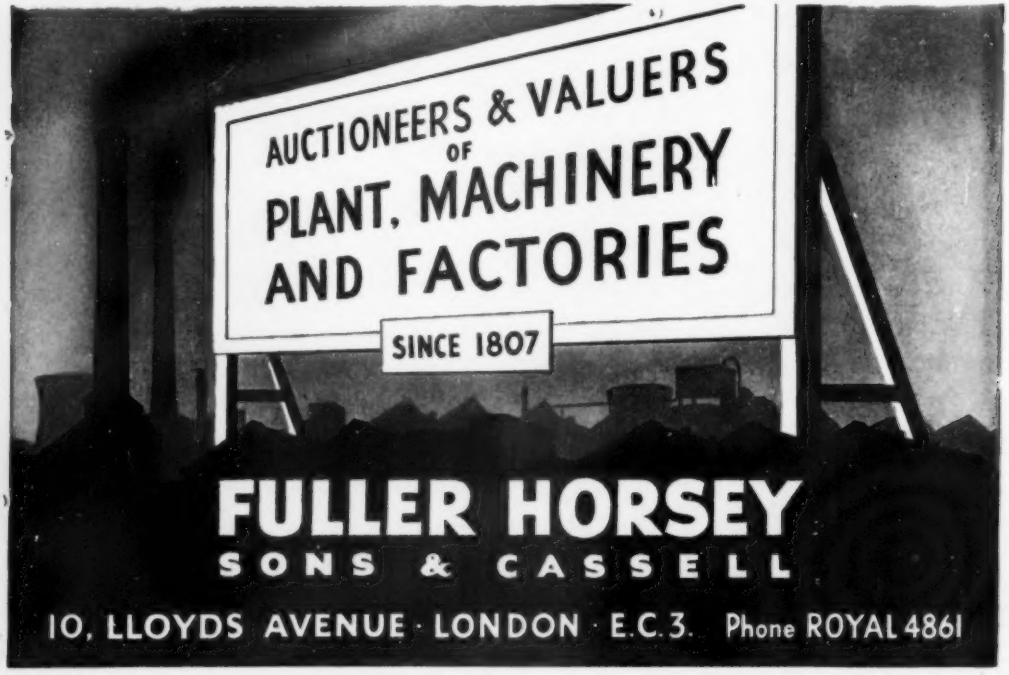

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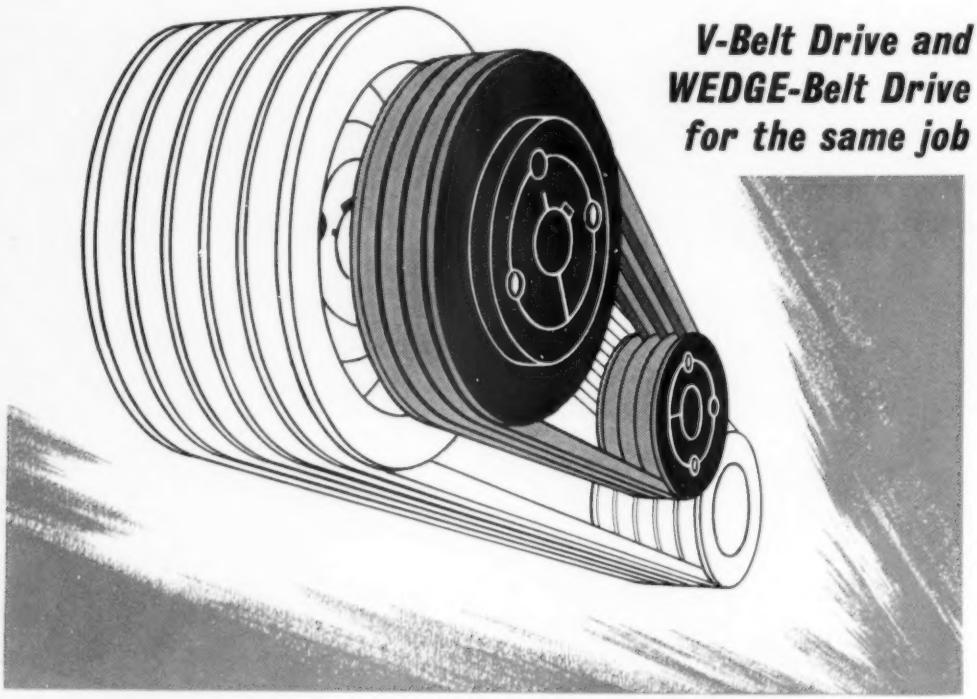

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	SAVING	**16%**	**12%**	**54%**	—	**5%**	**19%**	**36%**
25 H.P.	V-Belt	$6\frac{1}{2}$	$12\frac{1}{2}$	$5\frac{7}{32}$	6—B65	18·7	£17 · 0 · 7	66·8
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	SAVING	**18%**	**15%**	**48%**	—	**18%**	**32%**	**45%**
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100 H.P.	V-Belt	$10\frac{3}{4}$	$42\frac{3}{4}$	$8\frac{15}{16}$	8—C180	47·2	£86 · 2 · 4	530
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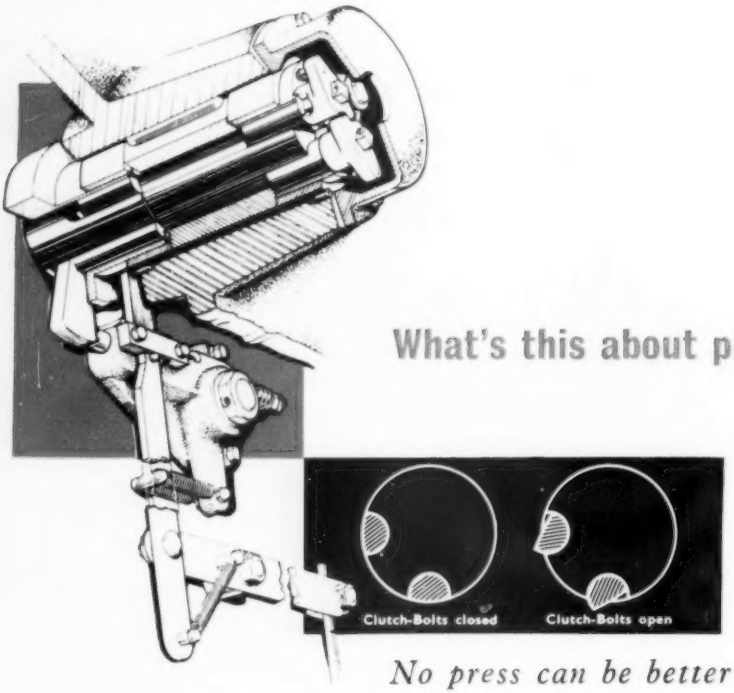

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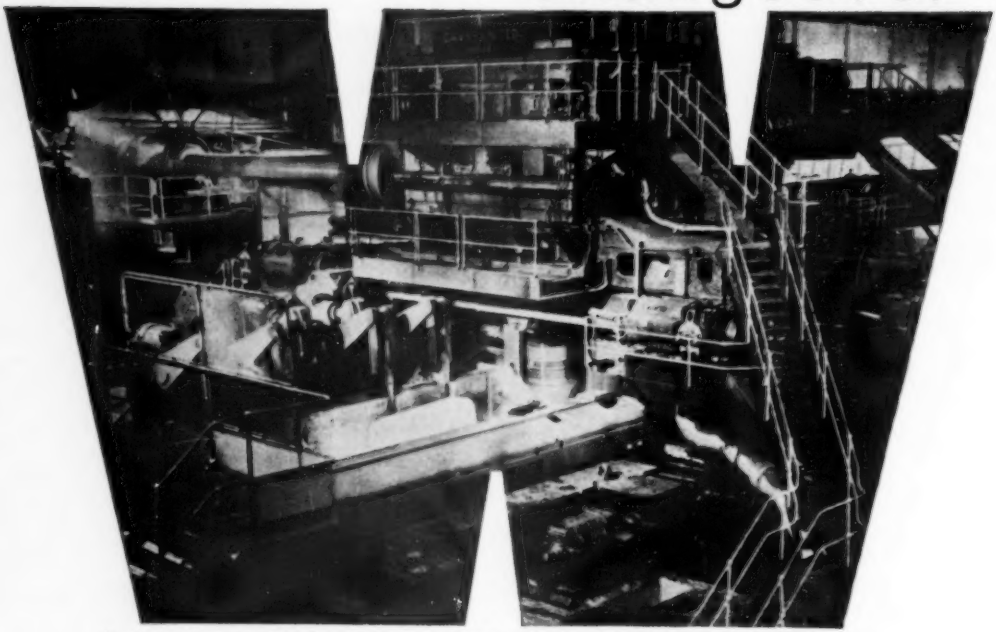

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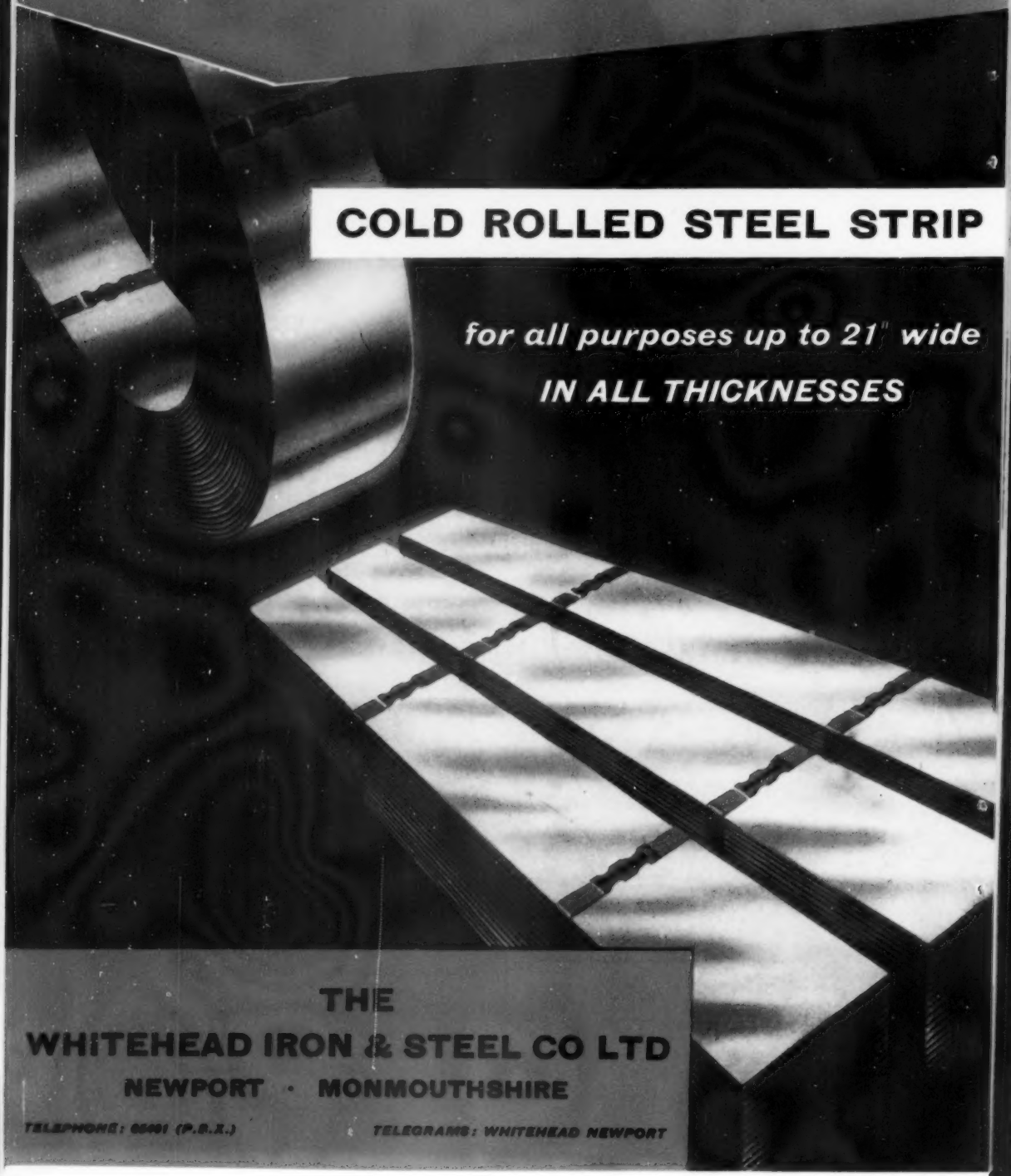

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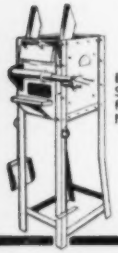
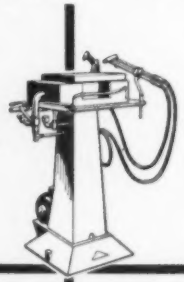
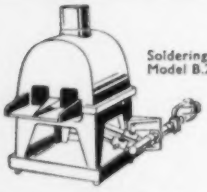


Brass Stamping Furnace. Model B.2183



PF.040 Furnace



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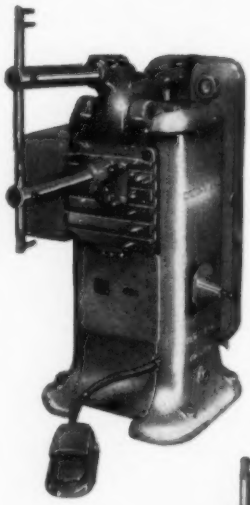

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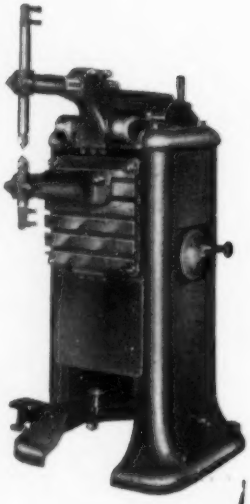

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M-W. 120

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All 'London'-clad hys ladie fayre
Dyd rescue, from that Foule Knyght's lare
(Who's cote was rusted past repayre)
Fyne prase, then, 'London' warents!

. . . now be it knowne and dulie recommendede to all who's wares mayketh reliable protektion a mater of grate moment*, that all thyngs mayed of 'London' hot-dyped sheets of ledecoting, dothe render them altymes well-tempered and sayfgarded.

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Setting the jaws to required distance with adjusting screw

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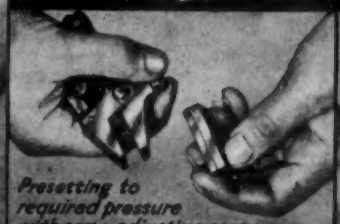

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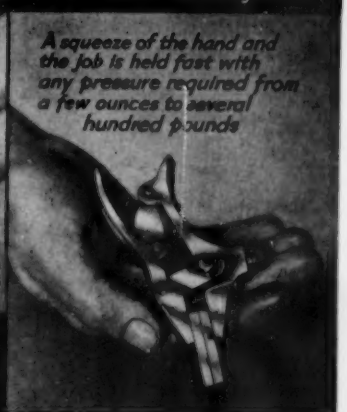

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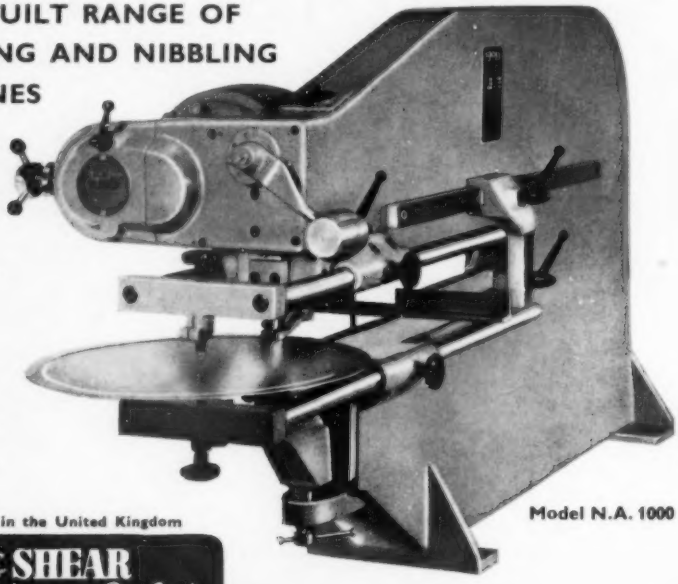

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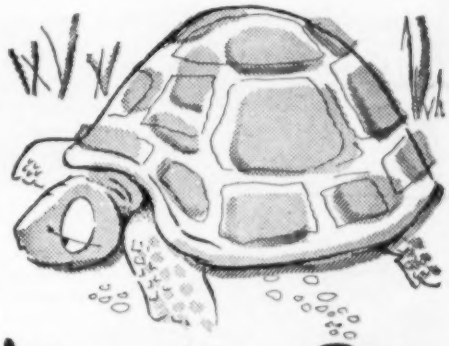

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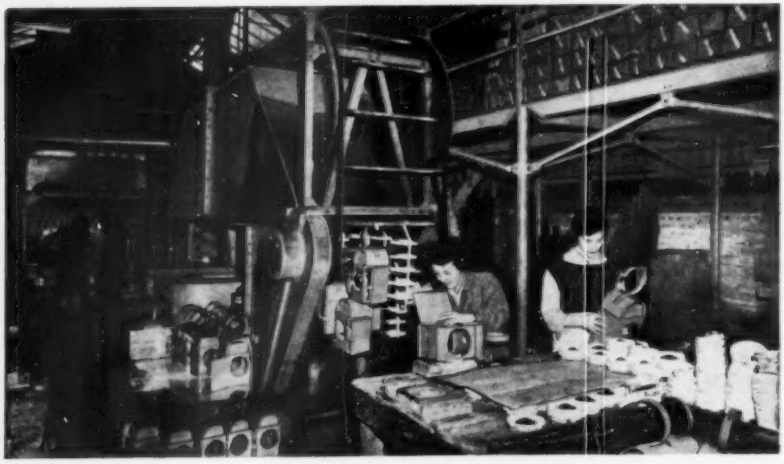

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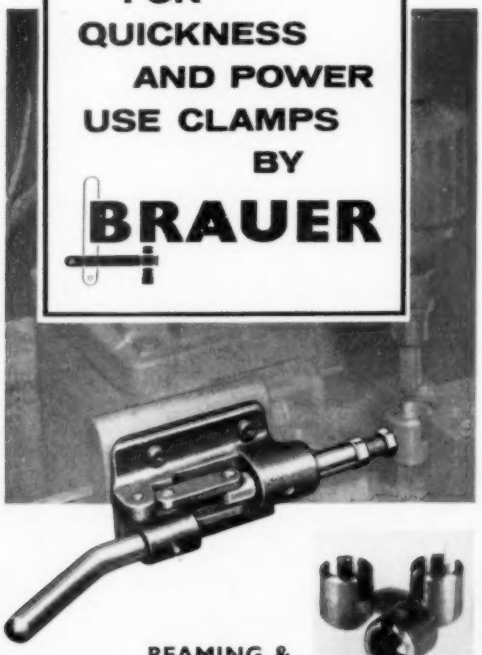

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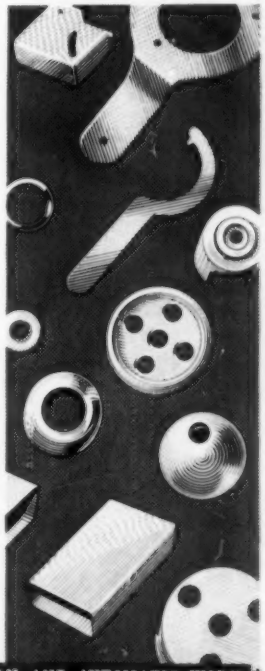

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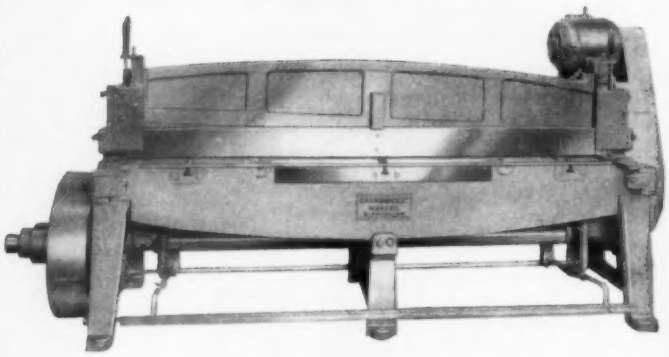

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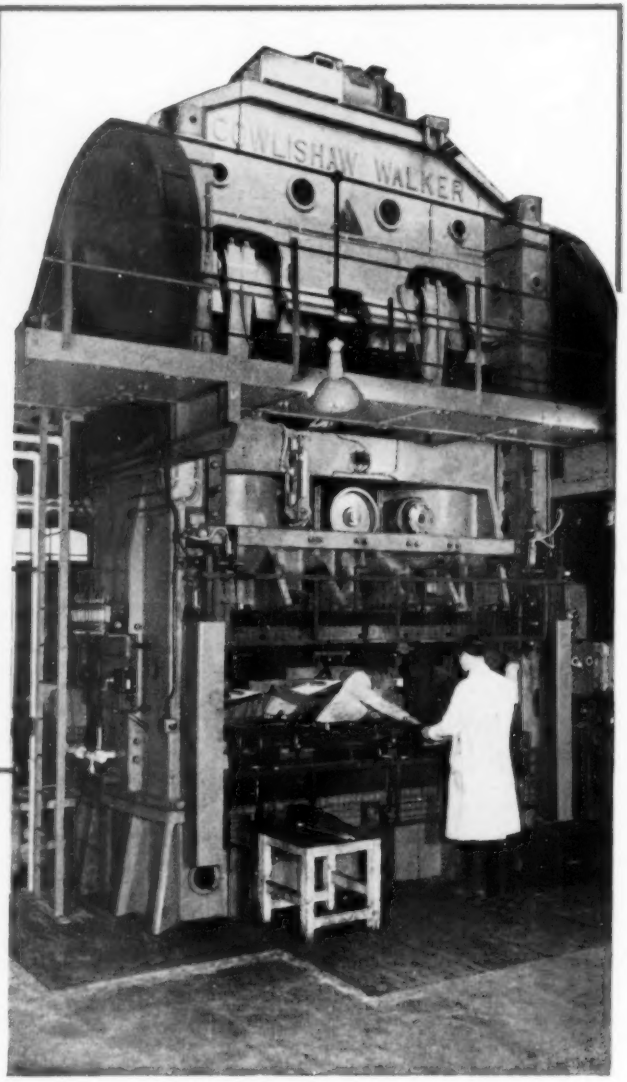

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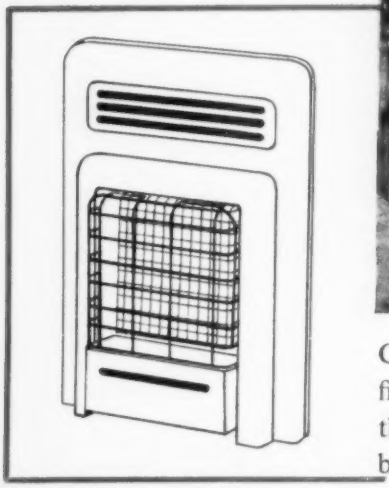

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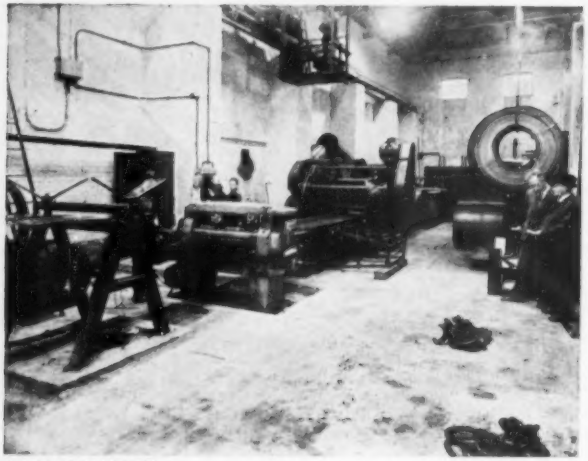

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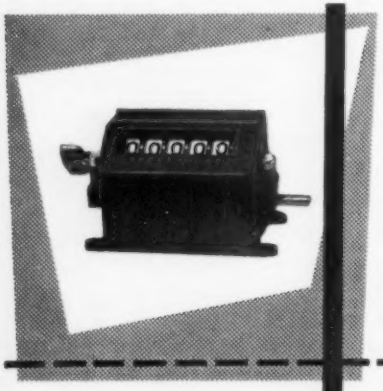

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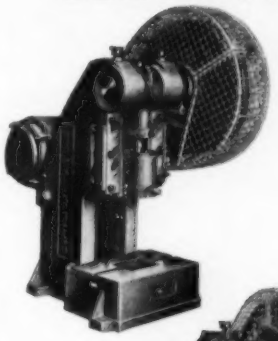
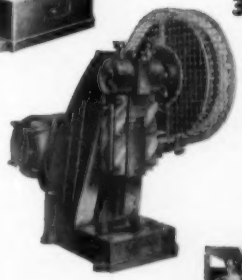
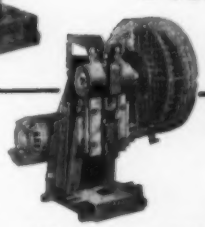


6 TON



3 TON



2 TON

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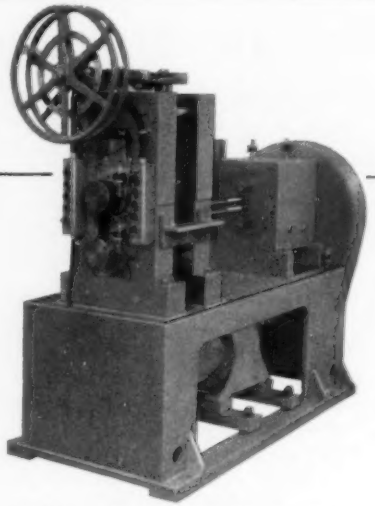

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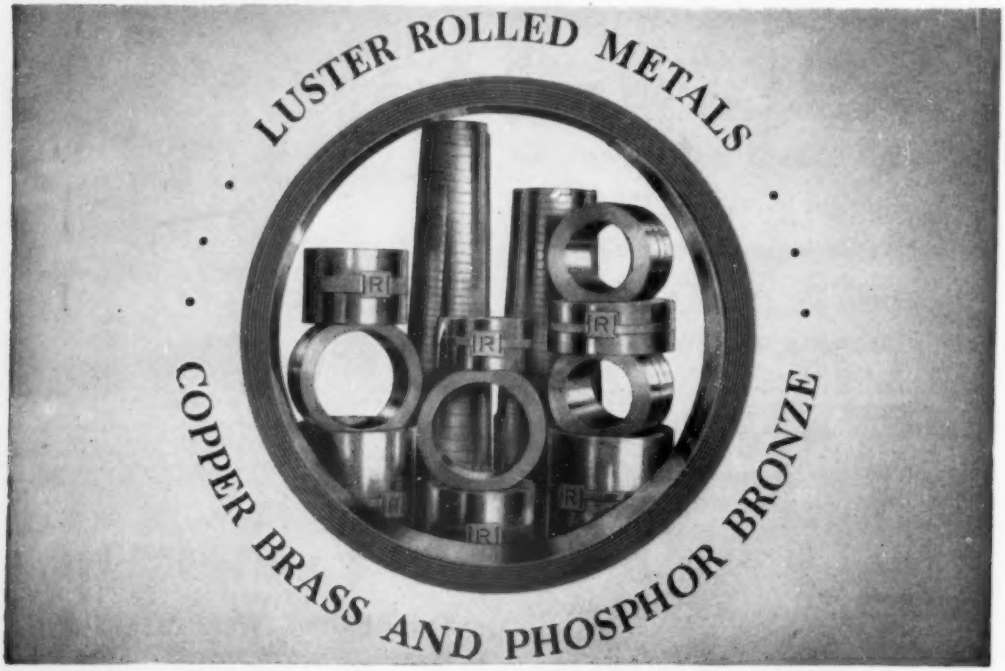

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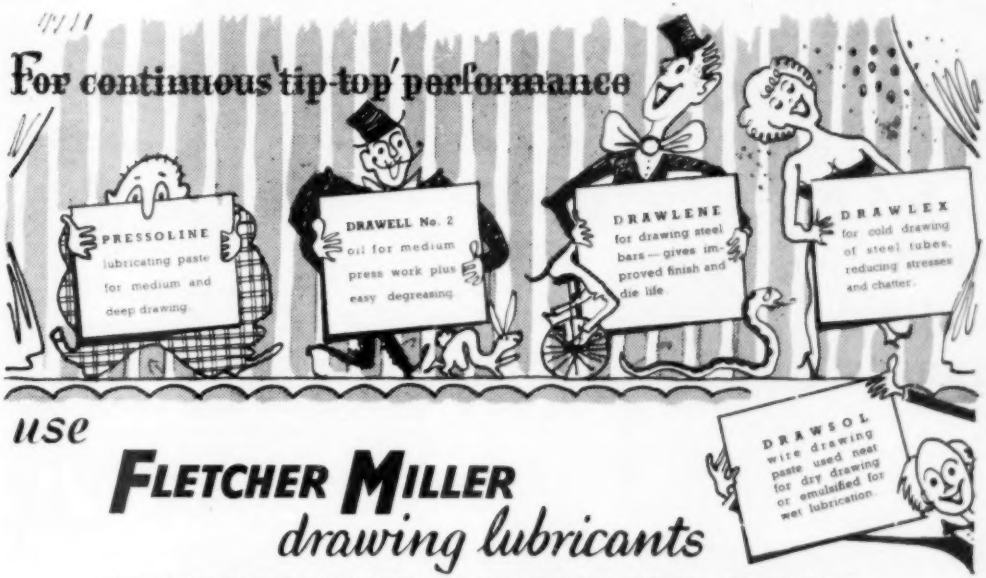
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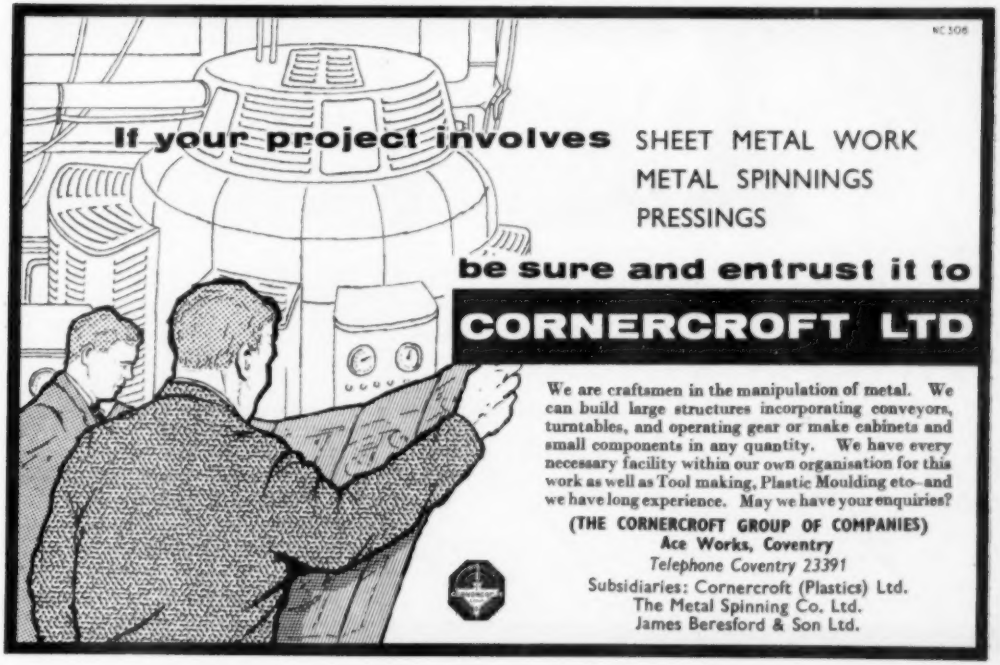
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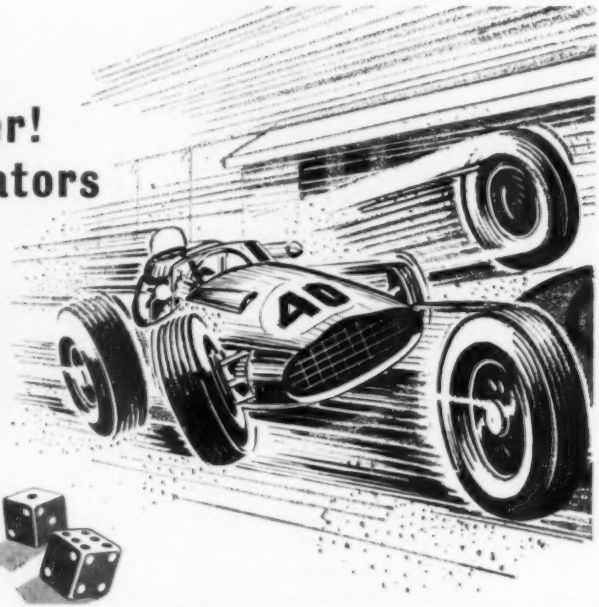

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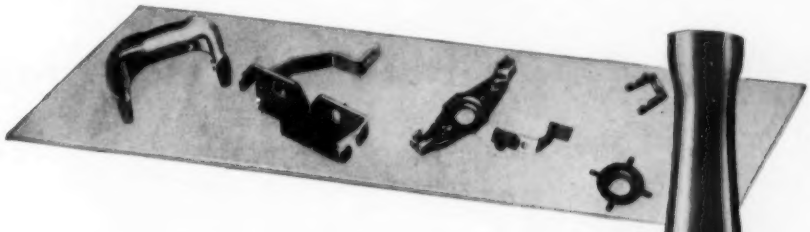

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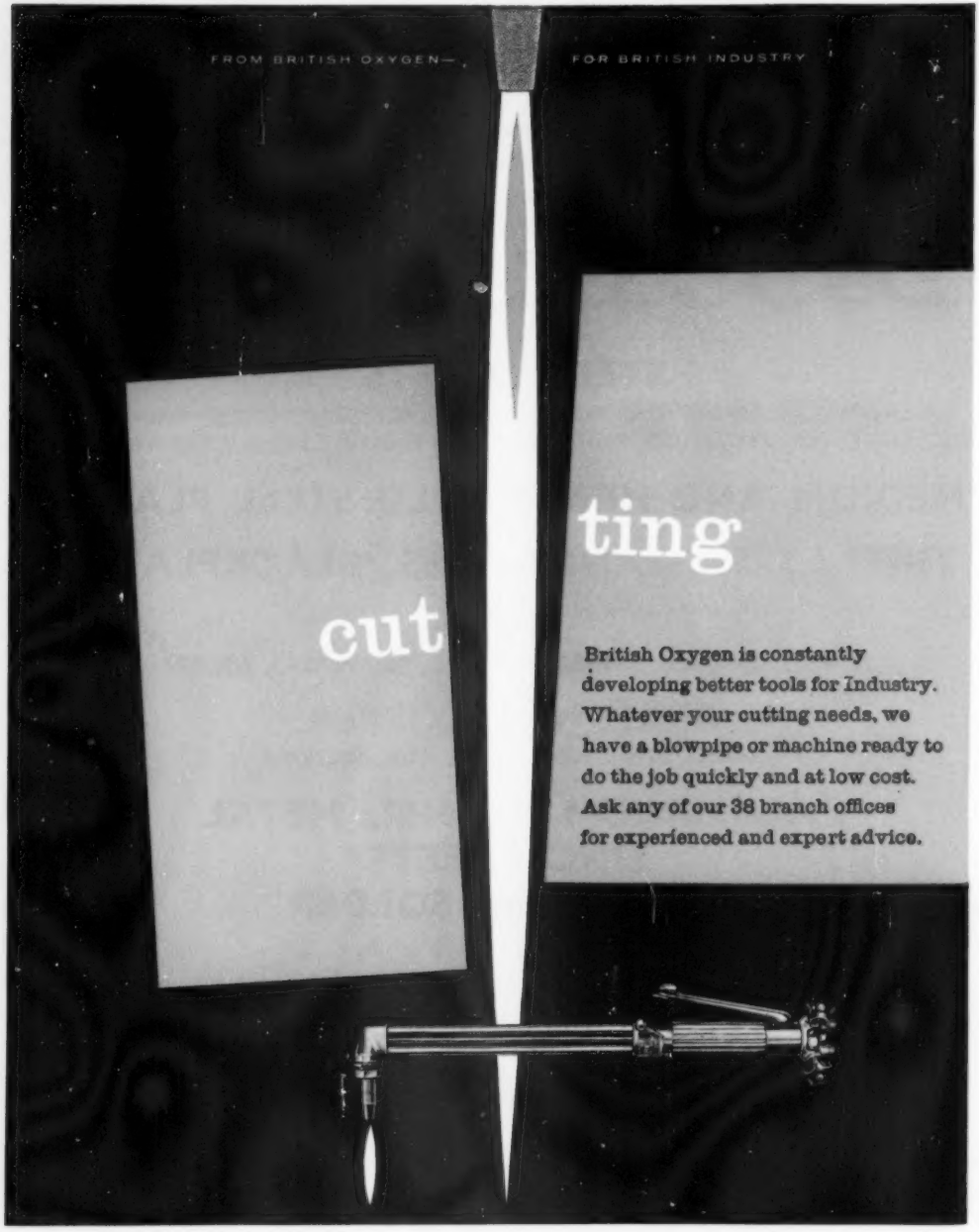
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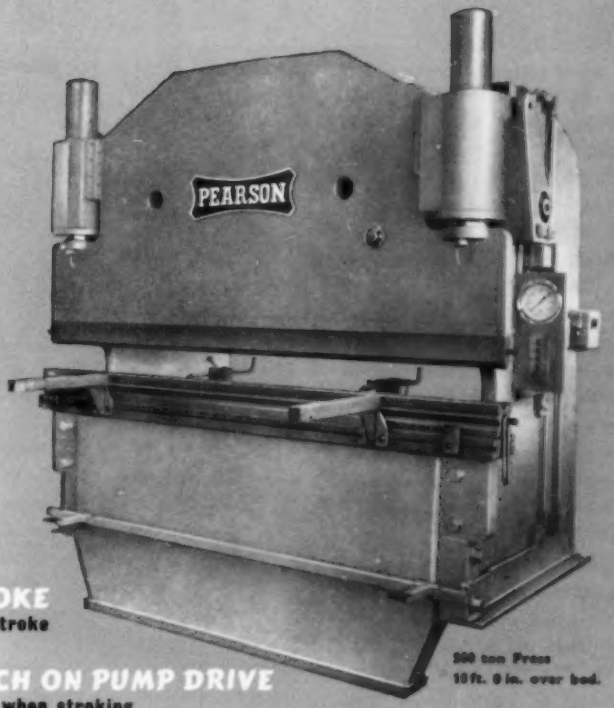

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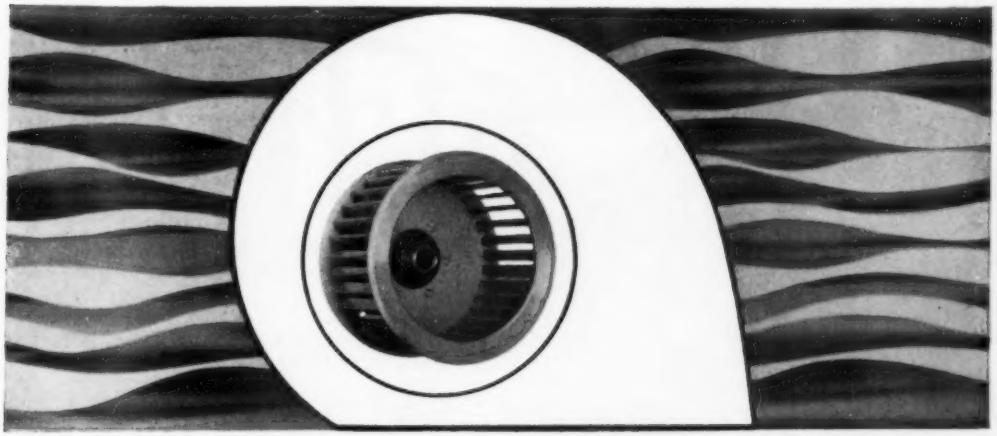

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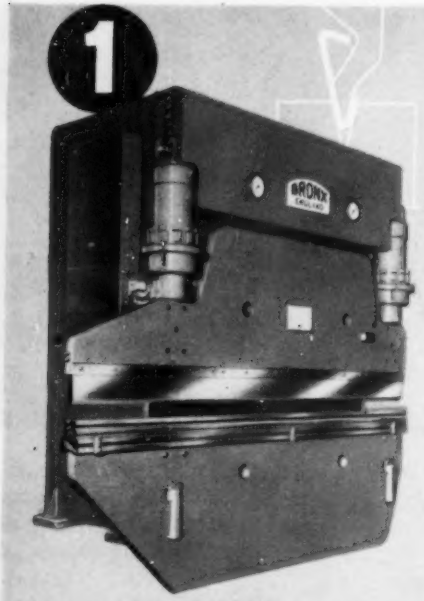

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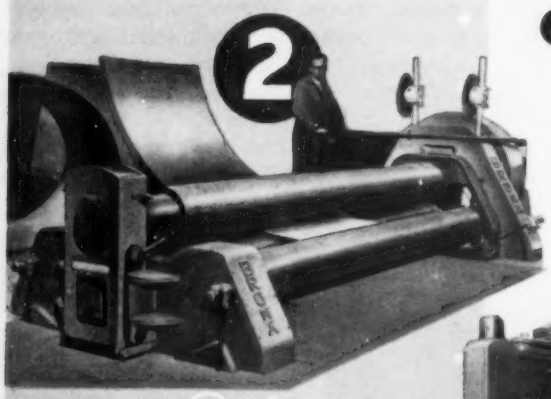

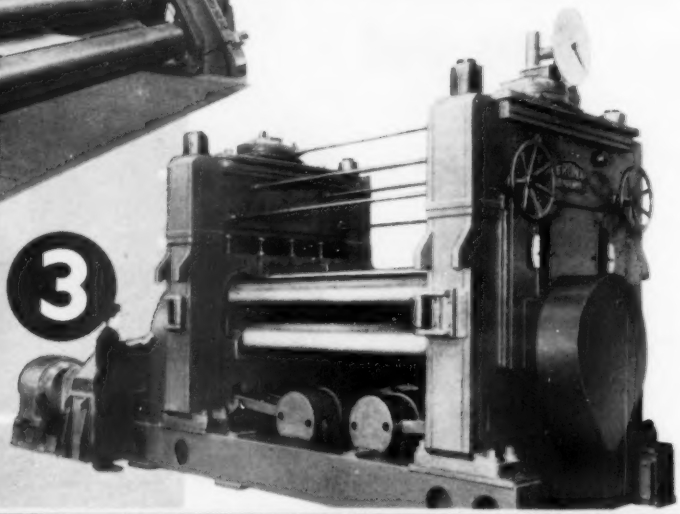

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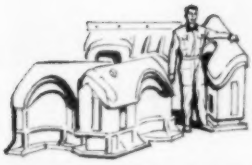

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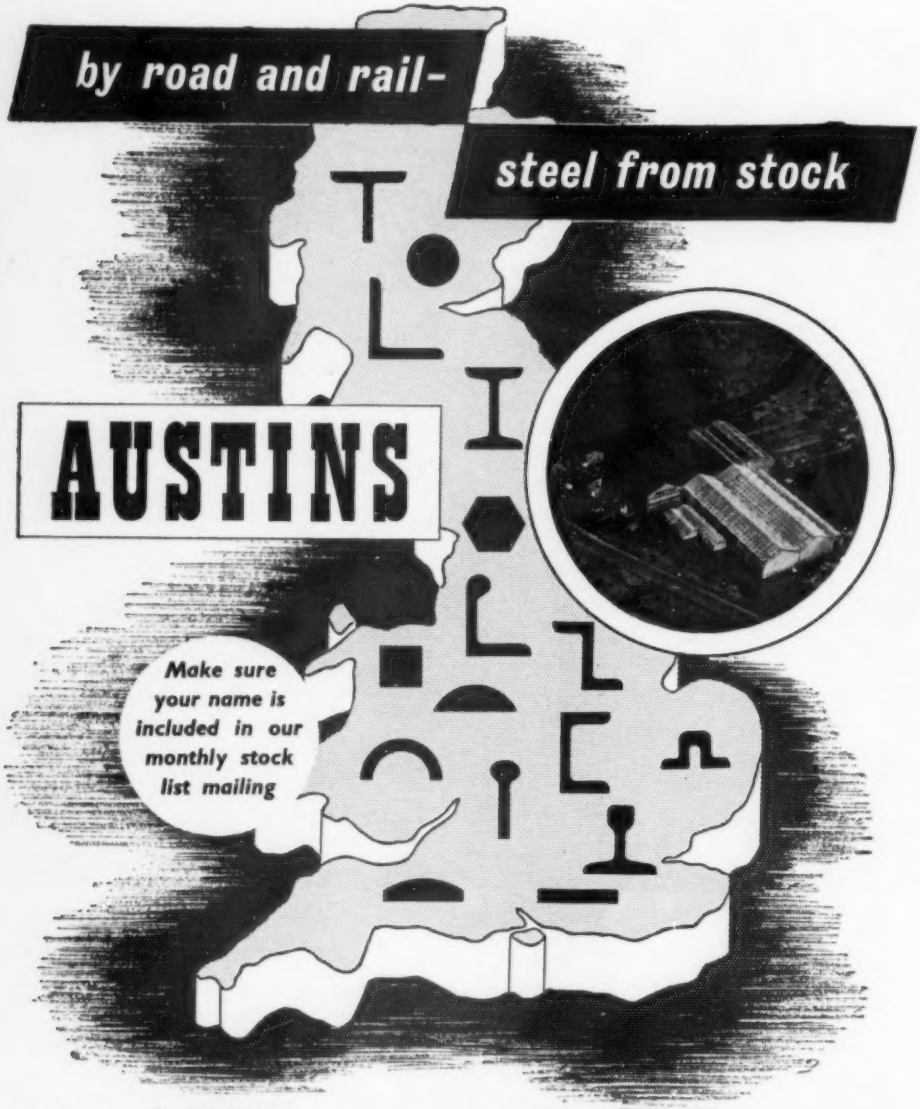

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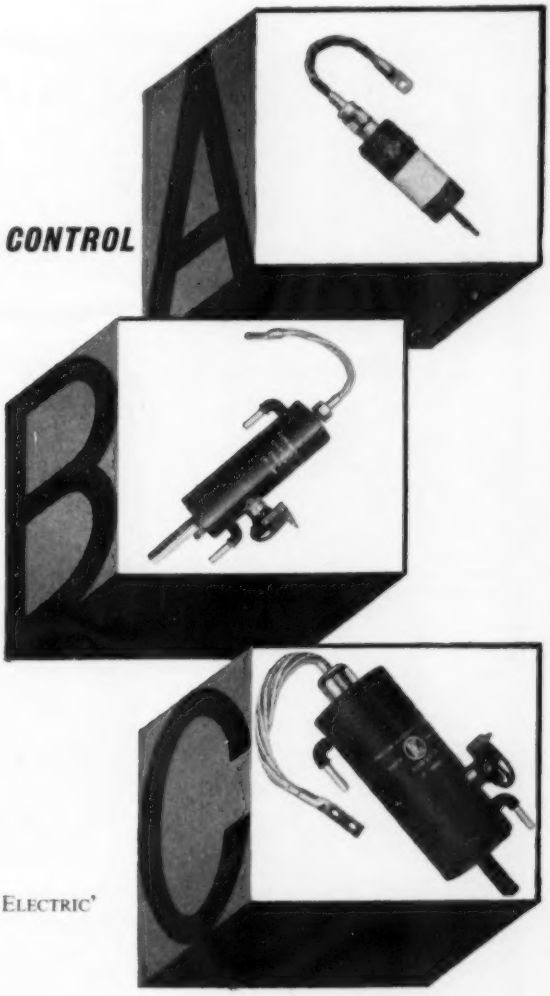

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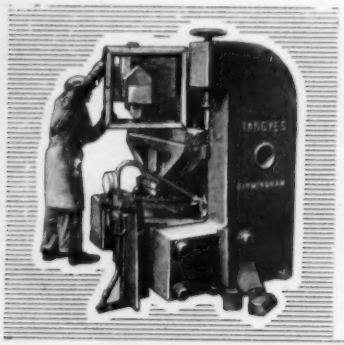


A FOUR-COLUMN DOWN-WORKING PRESS

This is typical of many presses in the high tonnage range. It is 1,000 tons capacity and incorporates various limit switches, volume control valves, time switch and push button control. An automatic cycle can be set in motion which can be pre-set to give a series of speed changes of the stroke as follows:—

(*a*) Fast Approach period; (*b*) Slow-down period; (*c*) Pressure build-up period; (*d*) Dwell period, holding the pressure.

At the completion of this pre-set cycle the ram returns rapidly to top position ready for next cycle which is commenced at the touch of a button.

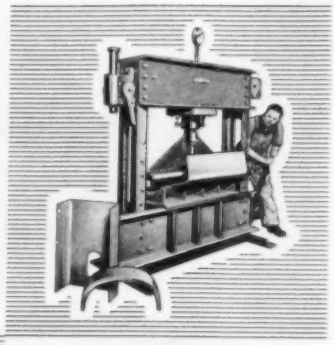
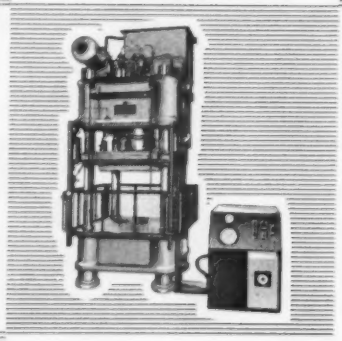


PLATE BENDING PRESS FOR BOX-SHAPE

The principal feature of this press is its balanced swinging head. This enables a box form to be completed after which the head is swung out of line with the frame to allow for the removal of the workpiece. This example is 100 tons capacity, is powered by one ram and accommodates up to 48 in. plate. Additional rams are used in accordance with tonnage required and width of plate. Details of various presses already developed can be supplied upon receipt of specific enquiries.



A GENERAL SERVICE PRESS

Most Tangye presses are tailored to suit a customer's particular needs but this is an example of one of the standard lines. It is available in 70 or 90 tons capacity (Brit. Tons.) and is of girder frame construction. Open sides allow any length to be accommodated up to 10 in. width and it is suitable not only for heavy general service purposes but its precisely controlled hydraulic power makes it equally effective for extremely delicate work. Daylight is adjustable from zero to 23½ in. and width accommodated is 48 in. between uprights. Power is supplied by a Tangye double-plunger type hand-pump but a motorised unit can be supplied.

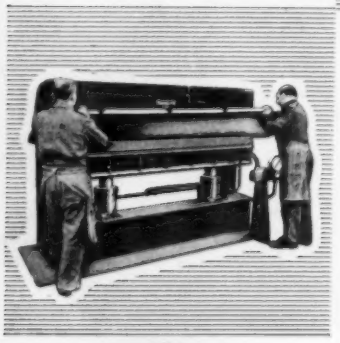


PLATE BENDING PRESS

This type of press is supplied in a variety of lengths and capacities. The one shown is 40 tons power and accommodates ½ in. plate 6 ft. wide. It has 3 in. daylight and tools and a 6 in. stroke, power is provided by a high-spued pump.

A single ram machine is supplied for plates up to 4 ft. wide and additional rams are added in accordance with size of plate and power required. In bending machines it is not only the gauge of plate but also the width of "V" opening on the tool which determines the power required.

HYDRAULIC PRESSES AND MACHINES

These examples are but a few of the large variety of "Tangye" Hydraulic Machinery and Equipment.

"Tangye" Hyraulic Power, in the experienced hands of the Hydraulic Division designers, is tailored to suit the exact operation it will be called upon to perform. It is therefore possible for us to gratify our Customer's every wish and we are not tempted to persuade him to "make do" with a standard design for we know we can offer something a little better.

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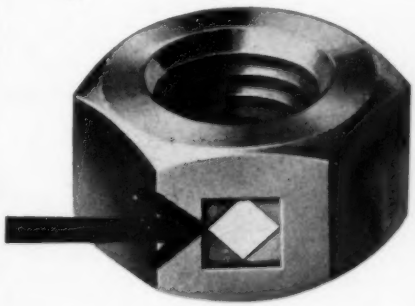

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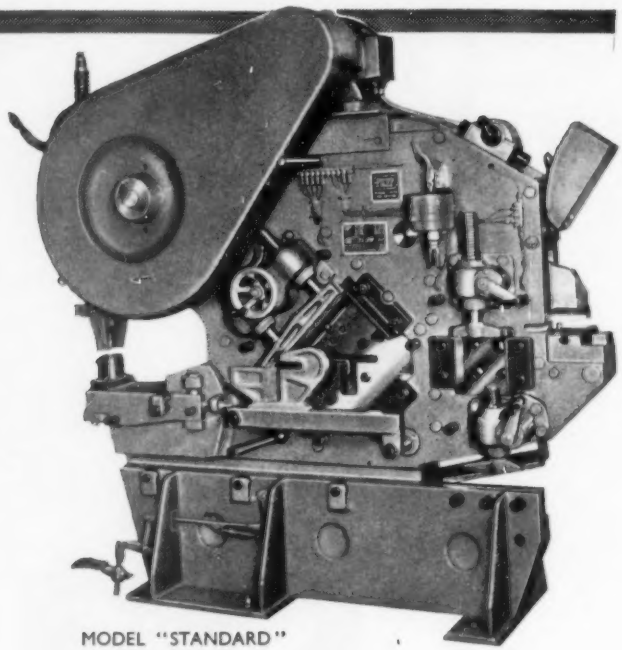

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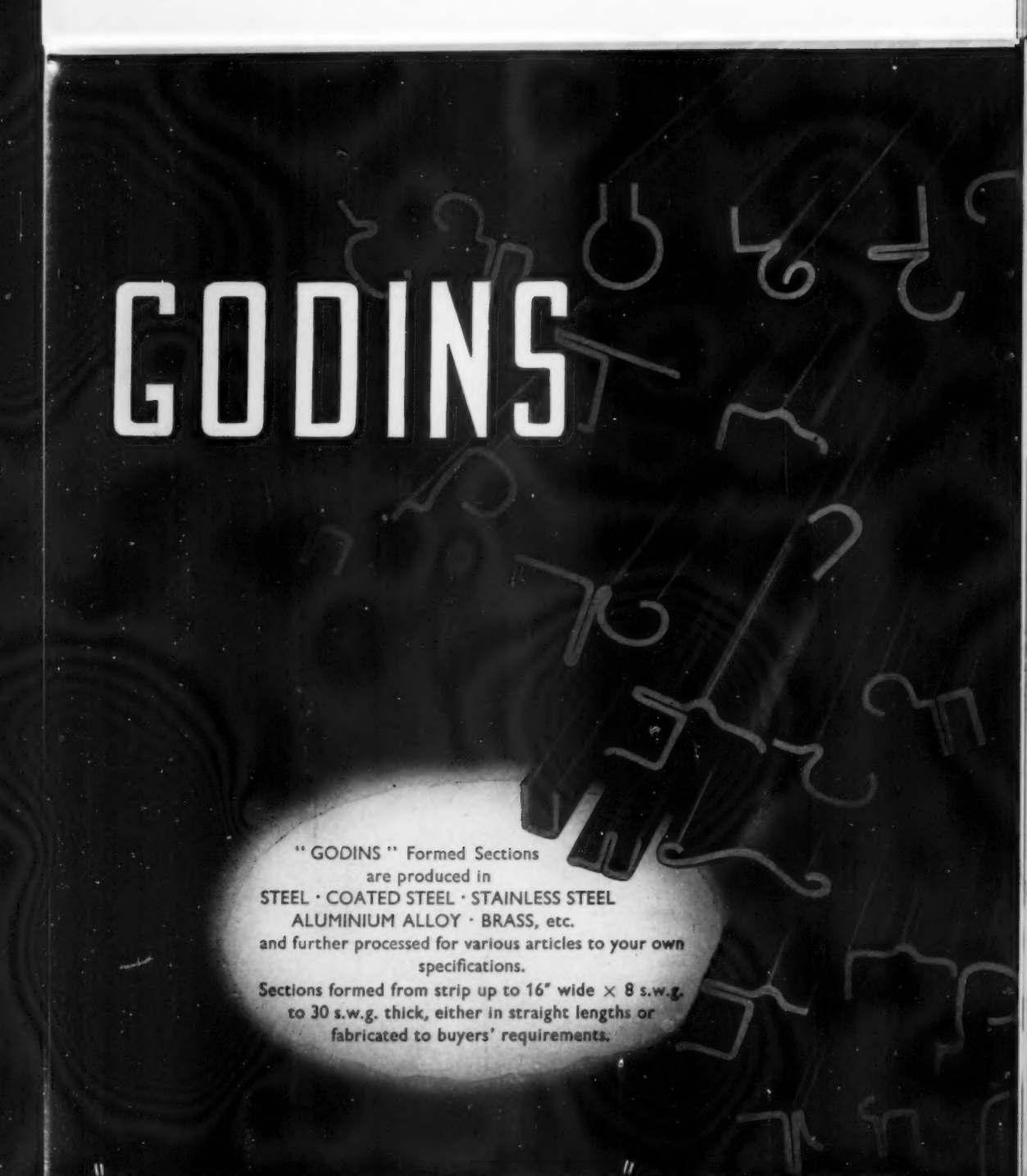

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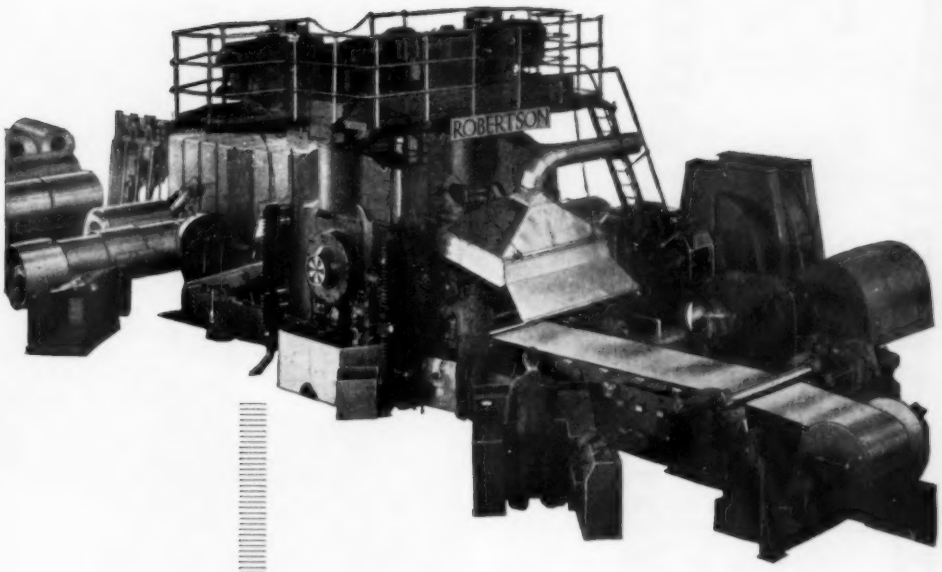

Four-high Reversing Cold-Rolling Mill
for aluminium and light alloy strip up to
50 in. finished width.

Photograph by courtesy of Société Industrielle de l'Aluminium, Duffel, Belgium.

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Reduce floor space, manpower and production costs with IWK Transfer presses

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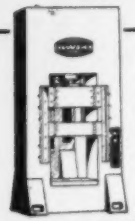
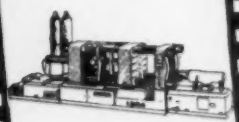
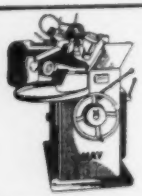


IWK HYDRAULIC PRESSES



IDRA
DIE CASTING MACHINES



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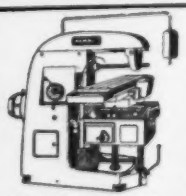
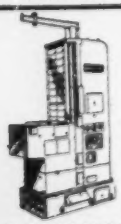
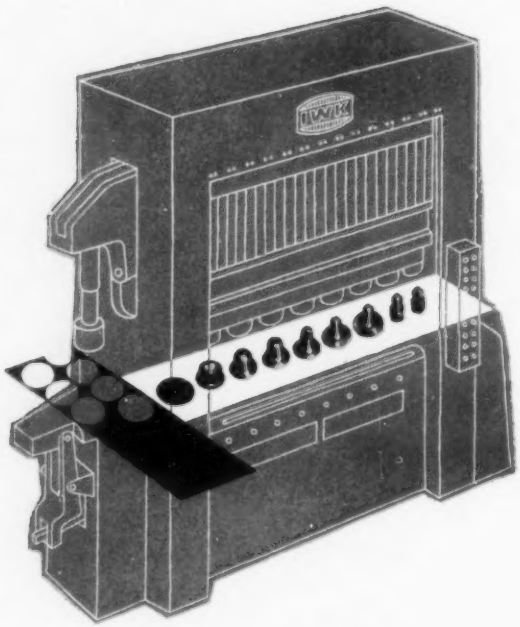


MAMMUT MILLING MACHINES



K. KLINK BROACHING MACHINES



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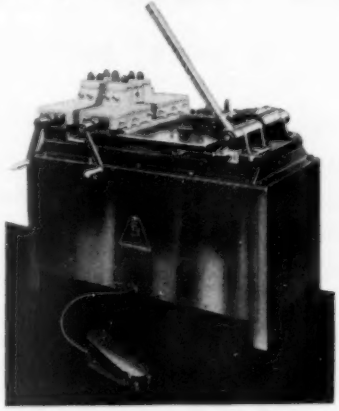

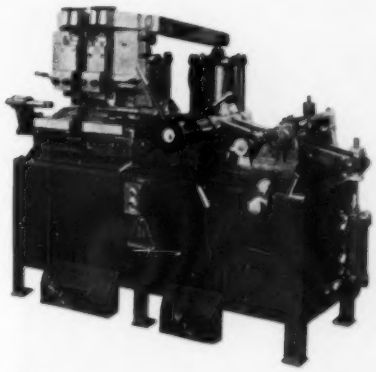

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200 K.V.A. Air Operated Automatic Flash Butt Welding Machine, combining Preheating before Flashing, and has been specifically designed for general production runs. Welding capacity 3½ square inches.

Manufacturers of all types of Welding Machines including foot and air operated pivot type Spot Welders, Vertical Sliding Head Spot and ProjectionWelders with full electronic control, Seam Welders, Flash Butt Welders, Rivet Heaters, Auto Wire Butt Welders, Vertical Sliding Head Electric Resistance Hot Closing Machines with full electronic control of pressure and current.

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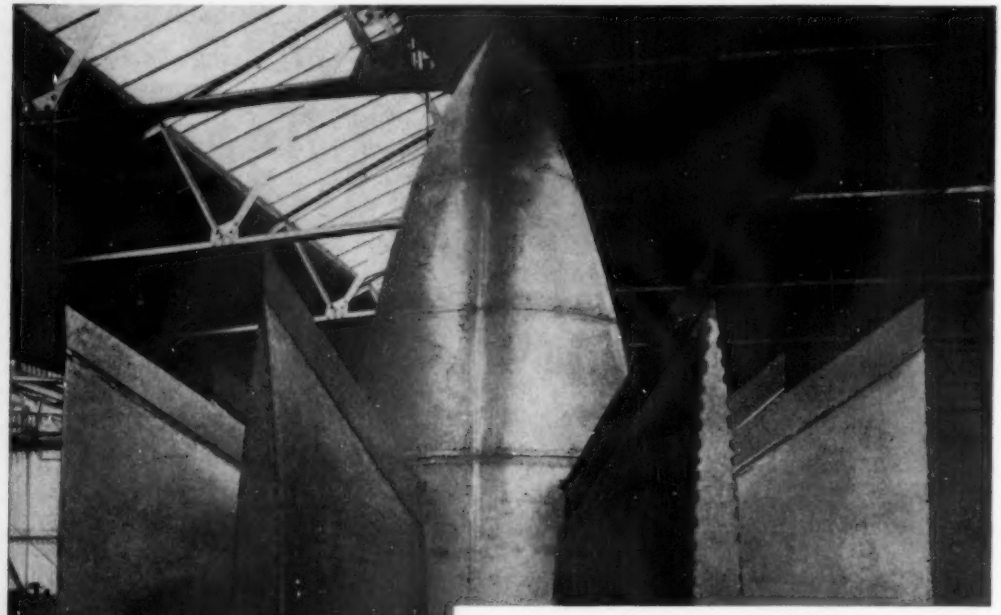

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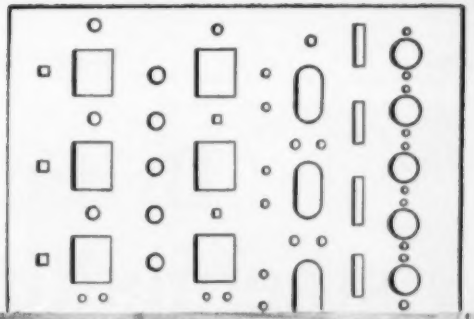

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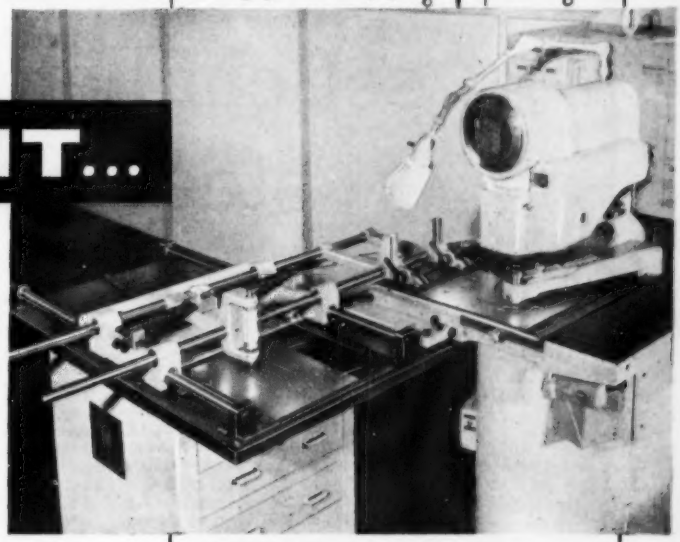

Ideal for short or pilot runs — model shop and experimental work. The patented punch, stripper and die button assemblies can be changed from one size or shape to another in less than 20 secs.

The POSITIVE DUPLICATOR converts the FABRICATOR to a medium run production machine for precision sheet metal work or for cold-punching printed circuit boards without heating, die-making, drilling or deburring.

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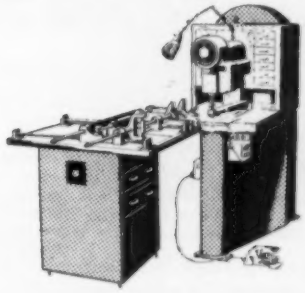
STROKE — $\frac{1}{8}$"
SHUT HEIGHT — 5$\frac{1}{16}$" stroke down (non-adjustable)
MOTOR — 1 h.p. 220/440v 3 phase. 50 cycle
STROKES PER MINUTE — 165 for single punching or nibbling
THROAT DEPTH OF PRESS — 15"
TABLE WORKING SURFACE — 30" wide x 20" deep.



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Britain's new steelmaking processes set challenge to steel men

The next ten years will be decisive for the future of Britain's steel industry. New methods are being developed which will change the established pattern of steelmaking. It is an exciting–and challenging–time.

The big new factor is oxygen. Ordinary oxygen from the air we breathe, but used as a pure gas, *by the ton*. In making steel it removes impurities more quickly and more cheaply than has ever been possible before.

New oxygen-making plant is being set up alongside the major steel works to deliver the gas along pipelines. About 3,000 tons of oxygen a day will soon be available.

Output: a 100% boost

Dr. Colclough, technical adviser to the British Iron and Steel Federation, has been a crusader for oxygen for 20 years. The great change that is making his vision practicable is that oxygen by the ton ("tonnage oxygen") is now available at a reasonable price.

FEDERATION'S COLCLOUGH
Crusader for oxygen

Dr. Colclough believes that, in Britain, oxygen can be used with greatest effect in the open hearth process, by which 85% of our steel is made. He says, "There is no question but that in the next ten years we shall see a revolution in open hearth steelmaking." Already, at the Appleby-Frodingham works in Lincolnshire, the open hearth furnaces converted to the Ajax process, using oxygen, have achieved outputs of up to 100% above those of conventional furnaces.

"The industry has gone a long way to solving the problems of using tonnage oxygen," says Dr. Colclough, "and many major steel developments of the future will be based on this principle. And by equipping the new oxygen-using plants with dust and smoke eliminators we are reducing the amount of air pollution caused by steelmaking."

New furnace, new methods

Another enthusiast for oxygen – though using it in quite a different way – is Mr. Emrys Davies, Works Director of Brymbo Steelworks in North Wales, which pioneered the large-scale use of oxygen.

At Brymbo, after the war, they had a blast-furnace (for making iron) and some old open-hearth furnaces (for turning the iron into steel). They were also making high-quality steels in electric arc-furnaces, mainly from scrap – because iron from a blast-furnace is much too impure to put into an arc-furnace.

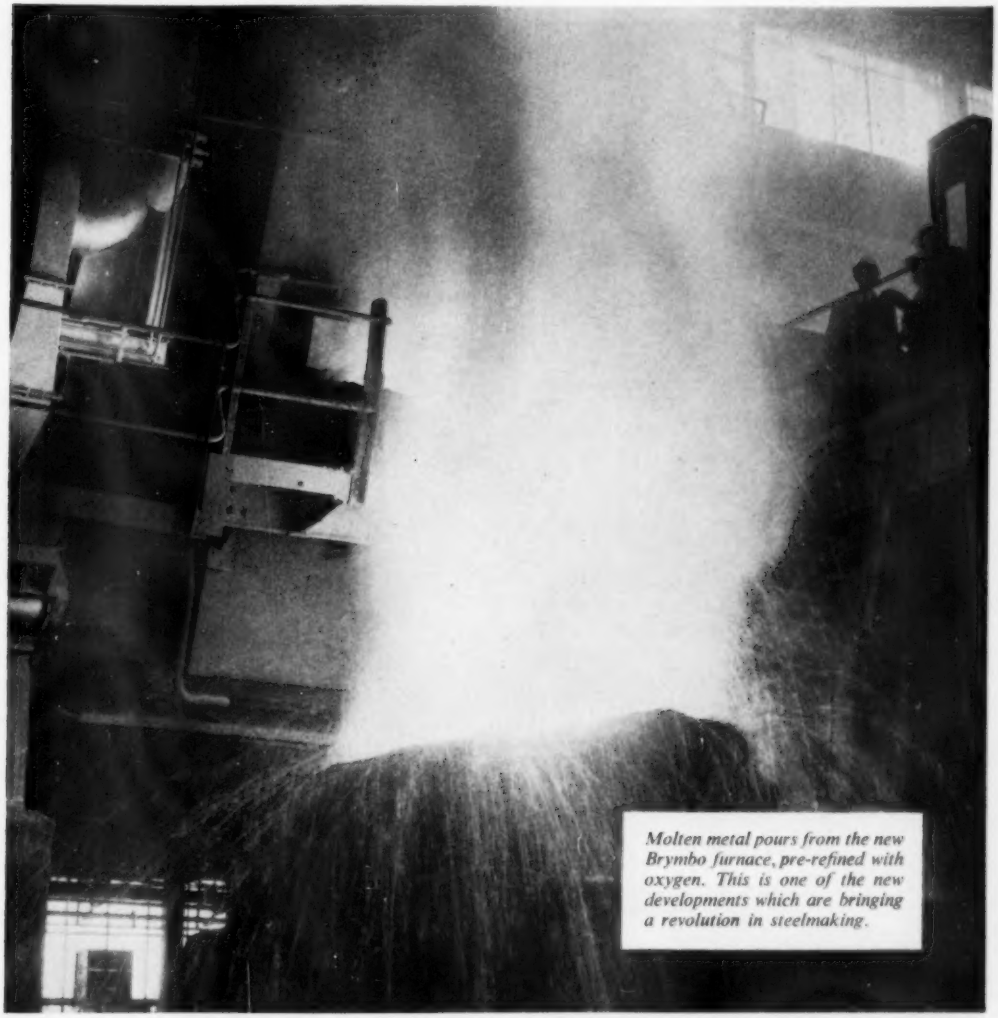
BRYMBO'S DAVIES
Steel at the cross-roads

They wanted to go over entirely to electric steelmaking. But it looked as though this would mean that they couldn't use the iron from their blast-furnace at all. Mr. Davies and his team developed an oxygen-blown furnace of wholly new design, to pre-refine blast-furnace iron before it went to the electric arc-furnaces.

Here are the makings of another revolution – because electric steelmakers have been chiefly dependent on supplies of scrap. Reducing this dependence could be very important – so much so that steelmakers as far afield as Japan are extremely interested in what is going on at Brymbo.

Less power, more steel

This completely new process has been embodied, daringly, in a £2 million development scheme, now proving its worth in full production. It has cut the time taken for the arc-furnaces to refine a charge of metal. It has reduced the electric power needed to refine a ton of steel from 650 units to 400 (quite important, when you consider that the Brymbo melting shop uses 10 times as much power as the whole of the nearby town of Wrexham). Outputs are up



Molten metal pours from the new Brymbo furnace, pre-refined with oxygen. This is one of the new developments which are bringing a revolution in steelmaking.

at least 25% – "a very conservative figure," according to Mr. Davies.

And whereas a Bessemer converter needs re-lining with special bricks after being used 80 to 100 times, the Brymbo pre-refining furnace has already been used 1,000 times. It has produced 25,000 tons of steel and will probably produce 10,000 more before re-lining is needed.

Most important of all, perhaps, the Brymbo process has signposted one possible way ahead for the whole industry: pre-refining can be applied just as successfully to open-hearth working. "Steel is at a cross-roads," says Mr. Davies. "The next decade of steelmaking will probably be the most interesting for 100 years. Great developments are taking place."

Oxygen is coming into its own, taking its place alongside iron ore, coke, and lime-stone, as a basic raw material in steelmaking. Already Britain's steel men can see that it brings higher output and lower costs. It will mean an all-round improvement of efficiency in Britain's already highly efficient steel industry.

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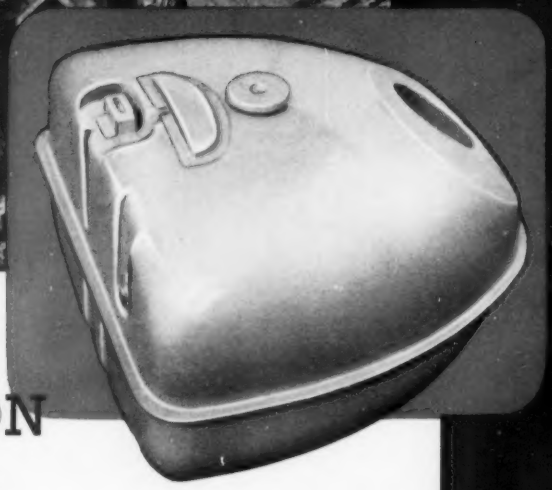

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Results for the Limiting Drawing Ratio in Swift cupping tests (50-mm. punch) performed on three independent presses for rimming and stabilized steel, 70/30 brass and aluminium are presented. The degree of control over testing conditions and procedure necessary to ensure good correlation is described. It was found that of the three materials examined aluminium imposed the strictest conditions and an increment in blank size of 1.25 mm. (0.049 in.) in determining Limiting Drawing Ratio appears to be too highly discriminating for this metal.

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The factor which was found to be most difficult to control was punch and die surface quality, so an investigation was carried out to determine its influence. Results are quoted for various combinations of surface roughness on punch, die and material, within the limits 0 to 20 micro-inches, centre-line average. Recommendations, especially in relation to working surfaces, are given for defining tool surface roughness in carrying out such cupping tests.

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"Tarentford"

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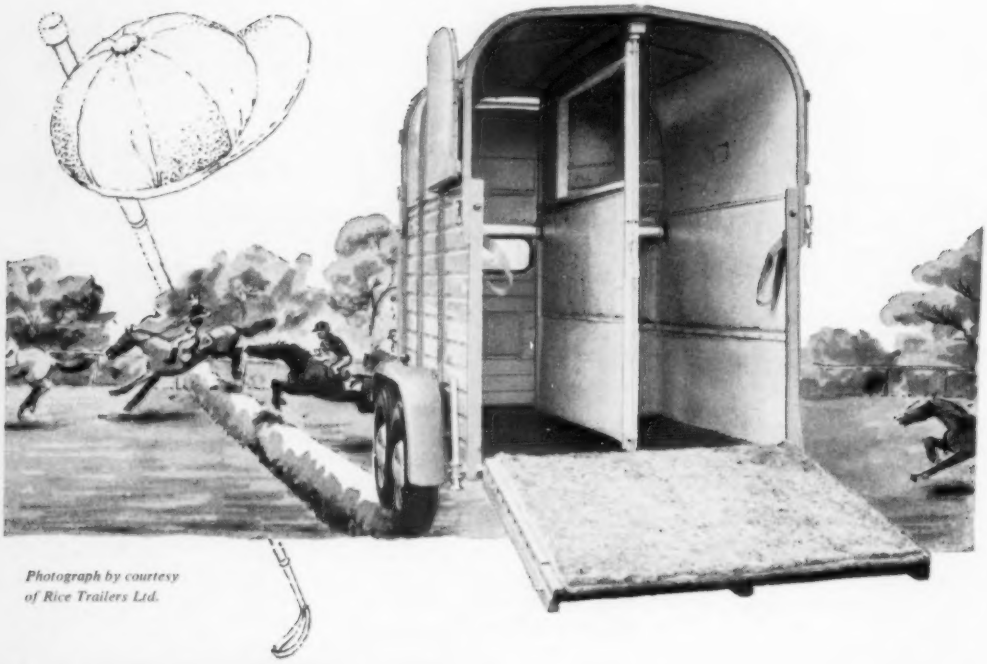

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In Memoriam

MR. BARRINGTON HOOPER, C.B.E., who died suddenly from coronary thrombosis on Friday, September 2, at the age of 75, was chairman of Industrial Newspapers Ltd., the company which he created 34 years ago and to the extension and development of which he had consistently and unremittingly devoted his undoubted genius in the field of publicity.

This found early recognition when, for the seven years up to the beginning of the first world war, he served on the staff of the "Daily Mail" under Lord Northcliffe, whose ability and concepts he always held in high regard.

This early experience led him into a number of outstandingly successful achievements, notably the promotion of the War Bond Tank Campaign in 1916, and the subsequent Victory Loan and the Food Economy Campaigns. For these services he was awarded the C.B.E. in 1920.

After a brief spell of political activity, promoting the short-lived National Party, in 1924 he was appointed controller of publicity for the British Empire Exhibition, Wembley, the prospects for which had at that time fallen to a low ebb, and there were few recollections which gave him greater pleasure than the outstanding and world-wide success which was ultimately achieved for that event.

In 1926 he formed Industrial Newspapers Ltd., in association with, among others, Mr. Harold Jeans, who later became chairman of the company with Mr. Hooper as managing director, an association which continued until 1955, when he also took over the chairmanship on the retirement of Mr. Jeans.

BARRINGTON HOOPER, C.B.E.

At the time of the company's foundation its journals, though of high repute, were relatively few, but the number grew steadily and the new approach and vigorous policy brought to bear on their publication launched a new epoch in trade and technical journalism.

Mr. Hooper was a man of wide interests, largely concerned with the fields of the journals he published and in particular he gave unstintingly his help and advice to those trade and technical Associations and Institutes with which the journals were associated. He was a founder Vice-President of the Sheet and Strip Metal Users' Technical Association, now the Institute of Sheet Metal Engineering, and this organization owes much of its comparatively rapid growth to a body of international status to Mr. Hooper's encouragement.

Few people have made so many friends in such diverse fields of activities as Mr. Hooper and his passing has been widely mourned. To his staff, his kindliness, tolerance and warm humanity, will long be remembered, for it was these qualities which gained for him their sincere affection, loyalty and respect.

SIR EDWARD THOMPSON, J.P.
Chairman of the
John Thompson Group

Production Procedures of JOHN MOTOR

This is the first of a series of articles car frames and chassis for commercial vehicles, but also many other components which typify company for large

Introduction

THE history of John Thompson Ltd., is a story of progress which is synonymous with this country's heavy engineering industries. Founded more than 130 years ago to manufacture canal boats and as general engineers, the company is today the parent of 23 fully developed companies with manufacturing facilities, in Great Britain and many parts of the Commonwealth, for complete steam-raising plant, special vessels for the chemical and petroleum industries, pressings for the motor industry, sewage-disposal plant and many others.

Starting with one small factory in Bilston, the Wolverhampton premises alone now cover over 80 acres and from an original handful of employees, which by 1880 had grown to 70, 7,000 are now employed in the Midlands factories, of which total 1,500 are employed in the subsidiary company, John Thompson Motor Pressings Ltd., with which this and succeeding articles will be concerned.

William Thompson, great-grandfather of Sir Edward Thompson, J.P., chairman and joint managing director of John Thompson Ltd., and of Mr. C. R. Thompson, managing director of the motor pressings company, was a boiler-maker and it was in this field that the name of Thompson established a world-wide reputation, before it was identified with other forms of engineering activity.

By the early 1900's many products had been added to John Thompson manufactures and, in consequence, the organization had grown considerably. Departments which were later to become independent companies formed part of the parent company, and each has become identified with research, development and production for the industries each serves.

Having such a wide range of activities, the Group requires a wide range of research to be carried out, and for this purpose the John Thompson Group Research Centre was established.

The main purpose of the Centre is not to carry out fundamental research, but to investigate and provide answers to specific problems passed on to it by Group companies. Many of these problems are concerned with research and development related to manufacturing methods. However, a large proportion of the work of the department is in connexion with customers' problems.

The centralizing of research facilities was a natural step in Group development. In order to make this centralization physical as well as organizational, an extensive group of new buildings was put up to house the department. These buildings include spacious chemical and physical laboratories, workshops and offices. Within this centre work is organized into five categories, each with a departmental head, and all under the direction of the Head of Group Research Laboratories. These departments are chemical laboratories, general engineering, combustion engineering, metallurgical, and welding.

Using the extensive facilities of the new buildings, the staff of the various departments are engaged on a number of projects. In particular, the rapid advance of nuclear engineering over recent years has required a considerable amount of research, and John Thompson's pioneering role in this field has led to a heavy demand on the resources of the Group Research Centre. Problems of heat flow

at the Beacon Works

THOMPSON PRESSINGS Ltd.

Mr. C. R. THOMPSON
Managing Director of
John Thompson Motor Pressings Ltd.

describing the production not only of motor- for which the company are world renowned, the wide range of techniques developed by the and small runs.

and heat exchange related to both conventional and nuclear sources of energy, have also commanded a great deal of attention. For these problems of heat transference, the staff of the Research Centre have at their disposal one of the best equipped laboratories of its kind in the country.

A typical example of one of the companies of the group is John Thompson Motor Pressings Ltd., today one of the leading producers of chassis frames and pressings for the motor industry. The company's origin was probably due to a conversation between a director and a member of his staff during a train journey, for it was shortly afterwards that a motor-pressings department was formed, using plant mainly borrowed from the boiler works, in a corner of which the first motor-car frame was made.

Fig. 1.—General view of original car-frame shop at John Thompson Motor Pressings Ltd

Fig. 2 (left).—First drawing operation on Hotpoint washing-machine bowl, showing run-out conveyor. Press is a 108-in. Clearing mechanical, 750 tons

Fig. 3 (right).—Second press on washing-machine bowl production, fitted with two sets of tools. Press is Clearing 600-ton mechanical

In 1915 a new works, comprising four bays, was erected and was progressively equipped with furnaces and hydraulic presses for the forming of heavy commercial vehicle chassis and mechanical presses for lighter pressings. Most of this equipment was designed and built by the company.

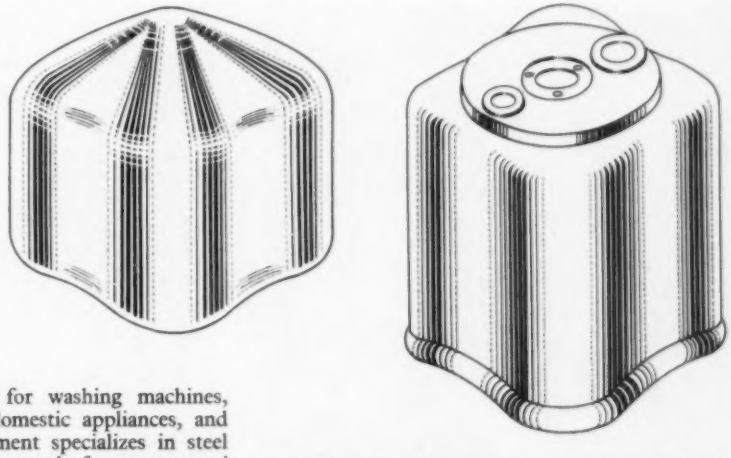
The motor pressings division now covers an area of about half a million square feet and several contracts initiated in the early part of the century have been continuously renewed, and frames for Rolls-Royce, Rover, Leyland, Vauxhall, A.E.C., Austin, Alvis, Daimler, M.G., Riley and Wolseley, are among these at present being produced.

Among the many interesting projects between the wars were the frames for many of the land-speed record cars, an example being the Napier-Railton in which the late John Cobb achieved 394.25 m.p.h. in 1947.

Today, in addition to the manufacture and supply of assembled chassis frames and chassis members, the company has a substantial output of other components for the motor trade in the form of axle-case housings, motor-unit casings, spare-wheel carriers and bumpers.

The company also manufacture railcar underframes, bogie frames and assemblies of both pressed and rolled sections up to 60 ft. long for British Railways, and doors and end frames for many types of railway wagons.

Among the many other components produced are



Figs. 4 and 5 (right).—Sketches showing two stages in pressing operations on washing-machine bowl

such items as pressings for washing machines, refrigerators, and other domestic appliances, and the constructional department specializes in steel fabrications and repetition work for contractors' plant in the form of cement silos, concrete pouring skips and scoops for earth-moving equipment.

It is the purpose of this series of articles to illustrate the wide range of activities of John Thompson Motor Pressings by describing the manufacture of several components typical of those in production, including detailed descriptions of the production of several motor-car frames and chassis for commercial vehicles.

SOME TYPICAL PRODUCTION PROCEDURES

Washing-machine Bowl

Wherever possible, flow production methods are used in the works, a typical example of this being the

Fig. 6.—After pressing, bowls are transported on overhead Monorail conveyor to subsequent operations

Fig. 7.—Trimming and beading top edge of tub using Oliver Quickwork machine

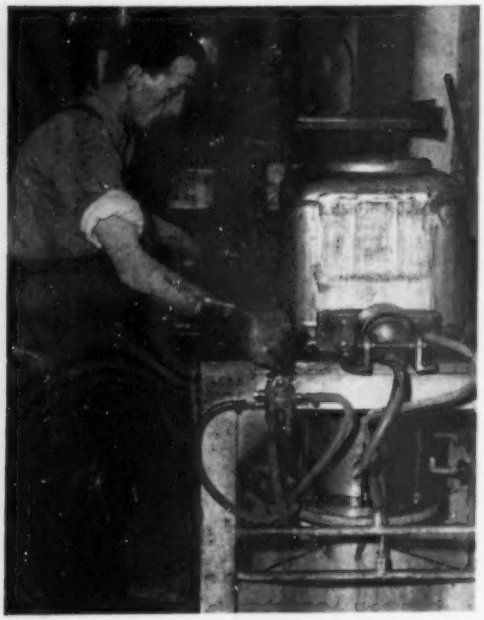


Fig. 8 (above).—Special John Thompson machine sizes trimmed edges to tolerance of $\frac{1}{32}$ in.

Fig. 10 (above).—Series welding wiring clip on to outside of bowl

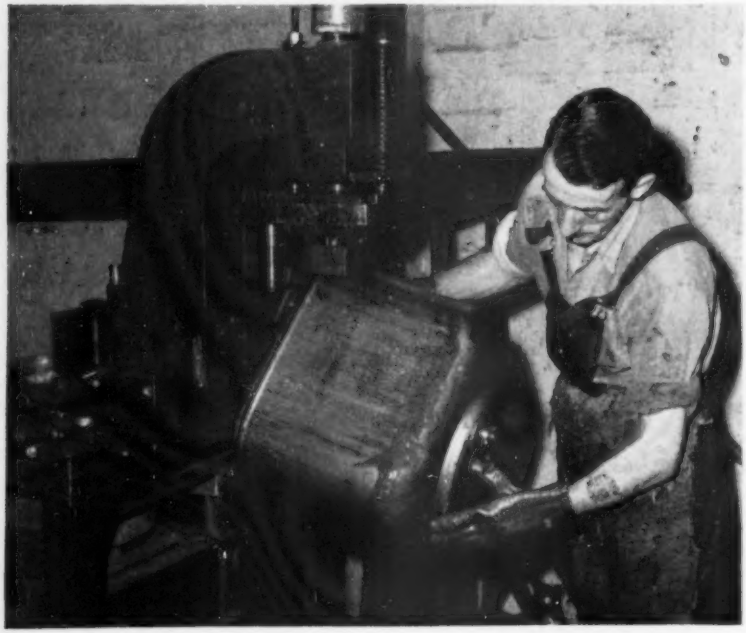


Fig. 9 (left).—The overflow pipe holes in the bowl are pierced and swaged in a John Thompson horn press

Fig. 11.—Completed bowls prior to despatch for vitreous enamelling

pressing and subsequent operations to manufacture the bowl for the Hotpoint washing machine.

Produced in extra-deep-drawing stabilized steel, the blanks for this component, 37½-in. dia. × 18g., are produced in a Wilkins and Mitchell 450-ton press.

A suction-lifter removes one blank at a time and feeds onto a conveyor leading into a two-high roll equipment in which drawing compound is applied to each blank. The push-button control on the drawing press starts the rolls and the lifter which are synchronized with the press. The first draw is effected in a 108-in. Clearing mechanical press (Fig. 2) which has a capacity of 450 tons on the inner slide and 300 tons on the blankholder. The stroke of this press is 33 in. on the main slide and 22 in. on the blankholder. In this first drawing operation the blank is drawn into the shape shown in Fig. 2. the depth being about 17 in. The dies used for this operation are chromium-plated.

Following the first draw the component is lubricated by hand (Duckhams P.S.C.), placed on a gravity roller conveyor which feeds a driven conveyor by which the component is taken to the frontside of a Clearing 600-ton hydraulic press rated at 400 tons on the inner slide and 200 tons on the outer.

Two sets of tools are fitted into this press (Fig. 3). In the first set the component is given a second draw which produces a square-shaped bowl with radiused corners 14¾ in. deep. The second set of tools, which are mounted in the blankholder, swages and pierces the bottom face of the bowl which contains three holes, together with provision for the agitator. (Figs. 4 and 5).

A Sick photoelectric guard is fitted to this press.

From the press area the tubs are transported by an overhead conveyor (Fig. 6) to a further station where, by means of an Oliver Quickwork machine, the top edge of the bowl is trimmed and beaded (Fig. 7).

The next operation involves the use of a special machine, built by John Thompson's, in which the trimmed edges are sized to a tolerance of $\frac{1}{32}$ in. (Fig. 8).

A John Thompson hydraulic horn press in the next station pierces and swages overflow pipe holes, (Fig. 9) after which the now almost complete bowl passes by gravity conveyor to a series welder in which a wiring clip is attached to the outside of the tub (Fig. 10). The use of the series-welding technique here eliminates marking of the inside wall of the bowl, which is subsequently vitreous enamelled.

Suspension Struts for B.M.C. Mini-Car

Each suspension unit, one for each wheel, on the B.M.C. Minicar consists of an inner and outer cone with rubber bonded between them. The inner cone is mounted on a strut and the suspension linkage is so arranged that the weight of the car acting along the axis of the strut tends to force the inner and outer cones together, so subjecting the rubber to a combination of compression and shear. The cross-section of the rubber and the formation of the flanged co-operating plate which bears on the outer surface of the rubber core has a critical effect on

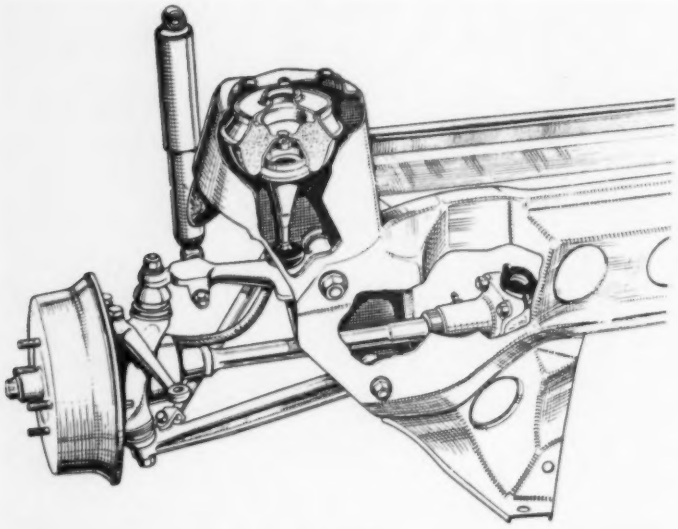


Fig. 12.—Cut-away drawing showing one front-suspension unit on B.M.C. Mini-Car (Courtesy British Motor Corporation)

suspension characteristics and has been developed by extensive experiment and photoelastic study.

The struts referred to earlier are of two types, one type, for the rear suspension, being much longer than that for the front suspension. At the rear the struts are horizontal, and the vertical wheel movements are transmitted to the struts by short levers attached to the forward end of trailing links.

At the front, unequal-length transverse links are used and the short strut acts between a point close to the inner pivot of the top link and an abutment immediately above, the lower end of the strut bearing on a nylon-seated ball joint with sealed-in lubricant (Fig. 12).

At John Thompsons a special section has been laid out for flow assembly of the short and long struts referred to above, the layout of this section being shown in Fig. 13 on which the flow of both strut types is shown. Fig. 14 is a photograph of the

Fig. 13.—Layout of assembly bay for struts. Short struts: (1) planish halves; (2) halves and co-operating plate assembled by special spot welder; (3) sleeve added; (4) large end closed; (5) de-scale; (6) small end closed; (7) rough ream; (8) ream and face to length and face sleeve end; (9) size large end to gauge; (10) de-grease; (11) paint and stove; (12) stamp trade mark and clean bore. Long struts: (1) two halves and co-operating plate assembled by special spot welder; (2) sleeve added; (3) automatic carbon-arc weld; (4) complete weld; (5) large end closed; (6) small end closed; (7) rough ream and face sleeve end; (8) ream and face to length; (9) size large end to gauge; (10) de-grease; (11) paint and stove; (12) stamp trade mark and clean bore

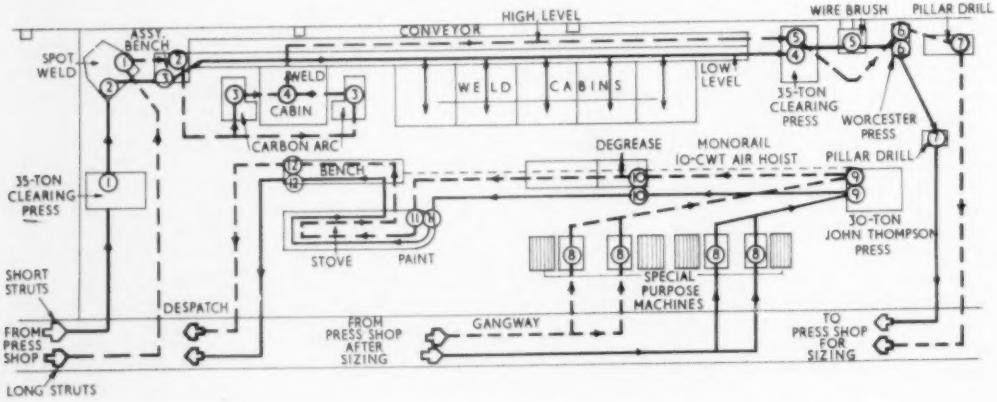


Fig. 14 (right).—Component parts of front and rear suspension struts for B.M.C. Mini-Car

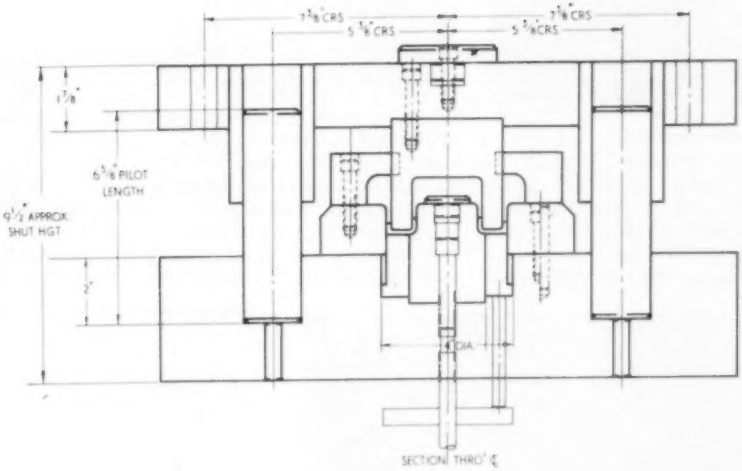


Fig. 15 (left).—Form tool for co-operating ring plates (shown at bottom of Fig. 14)

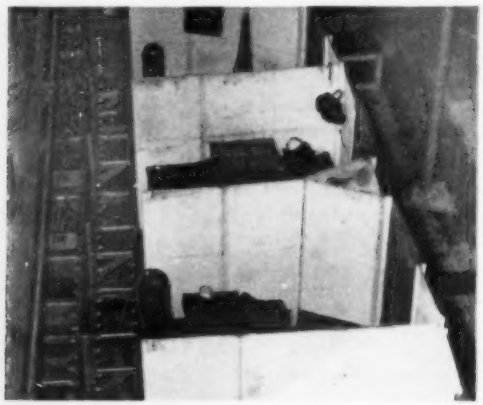
component parts of each type of strut which are also shown completed.

The material used for the struts is En2B in 14 gauge for the pressings and 12 gauge for the co-operating rings. The struts, as can be seen from Fig. 14 are of circular cross-section and are tapered from one end to the other. The wide end of the strut is shaped to take a cooperating ring plate and over the narrow end is placed a sleeve which incorporates a tapered portion.

The main part of each strut consists of two pressings which are blanked two at a time in a 200-ton open-front Bentley press fitted with a Bowfeed. The blank is a developed and proved shape.

The blanks are formed into half pressings in a 75-ton Clearing press and the pressings for the long struts are planished (in the main press shop) in a 60-ton Taylor and Challen press, after which they are transported in bins to the special section devoted to strut assembly. The short-strut half pressings are planished in the special section on a 35-ton Clearing press with a 4-in. stroke. The co-operating ring plates are produced in the press shop from a circular blank during the production of which the inside diameter is also pierced. The press used is fitted with a scrap cutter. Fig 15 shows the form tool used.

The next operation on the ring plates is to plunge and raise.



Strut Assembly

For each type of strut preliminary assembly is by hand. The two half pressings are placed together and the ring plate pushed on to the wider end of the pressings. The assembly is then placed in a special 3-head spot welder (Fig. 16) built by Burnley Aircraft, in which arms locate the ring downwards and the 3 heads index inwards to spot weld the ring to the two half pressings.

The solid drawn and extruded sleeve is then assembled to the narrow end of the half pressings by hand in a gauge so that the sleeve end is flush with the end of the narrow end of the assembly.

The short struts are then loaded into boxes and pass by gravity roller conveyor to the weld cabins (Fig. 17) where the complete assembly is metallic arc welded by hand.

The long struts are carbon-arc welded on an automatic machine built by Burnley Aircraft (Fig. 18). In this specially-made equipment (of which there are two) the two longitudinal seams joining the two half pressings and the circumferential seams for the ring plate and the sleeve are effected except

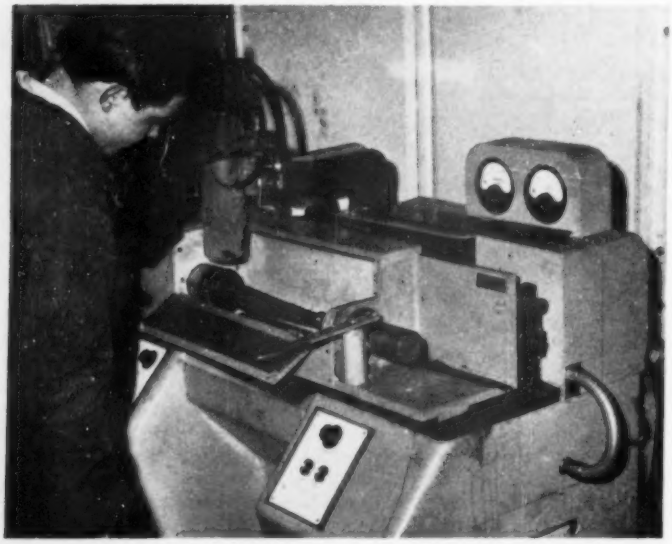


Fig. 16 (above, left).—Special Burnley Aircraft 3-head spot welder

Fig. 17 (above).—Gravity roller conveyor and weld cabins

Fig. 18 (left).—Special Burnley Aircraft automatic carbon-arc welder for long struts

for about 1 in. which is welded by hand.

Both types of struts, in bins, then travel on the gravity roller conveyor to a 35-ton Clearing press in which the large ends are closed. Following descaling by wire brushing (short struts only) the next operation is effected on a Worcester press; in this operation the small ends are closed.

For the next operation, rough ream and spot face sleeve end, two pillar drills are provided, one for each size of strut. Following this, both types of struts are taken back to the press shop where, in a 200-ton Bentley press, the large-end diameter is sized to within 0.002in.

After sizing, both types of struts are returned to the assembly section and in special-purpose machines built by John Thompson's the large end of the struts is trimmed to length and the small end is finish bored and hand reamed during the work cycle (Fig. 19). A plug gauge is used for checking final "roundness" of both ends, the large end being sized finally in a 30-ton John Thompson press.

After this station the struts are loaded into baskets and transported on overhead Monorail to an Edgar Vaughan hot emulsion clean, after which they pass to an automatic paint spray plant.

This continuous plant (Fig. 20), built by Berridge Aircraft Ltd., is conveyorized and takes both types of strut. The struts are placed in jigs on the conveyor which takes them through an automatic black paint spray fitted with oscillating spray guns of Bullows manufacture. Both the inside and the outside of each strut are painted.

From the paint spray the struts are conveyed through an electric infra-red stoving oven; the time cycle from load to unload on this plant is 18 min., and the output is 230 struts per hour.

The final operations are to clean the bore and stamp on the trade mark on each strut, following which the completed struts are despatched.

M.G. Front Suspension Member

This front suspension member for the M.G.A. illustrates the company's approach to the production

Fig. 19 (above).—Special-purpose machine; face to length, chamfer both ends and ream bore (long struts)

Fig. 20 (right).—Automatic paint spray plant and stoving oven (Berridge Aircraft)

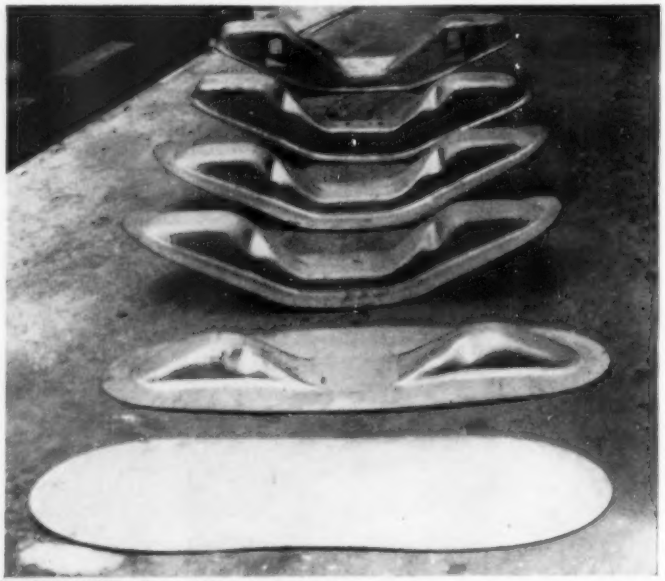


Fig. 21 (right).—Production stages for M.G.A. front-suspension member

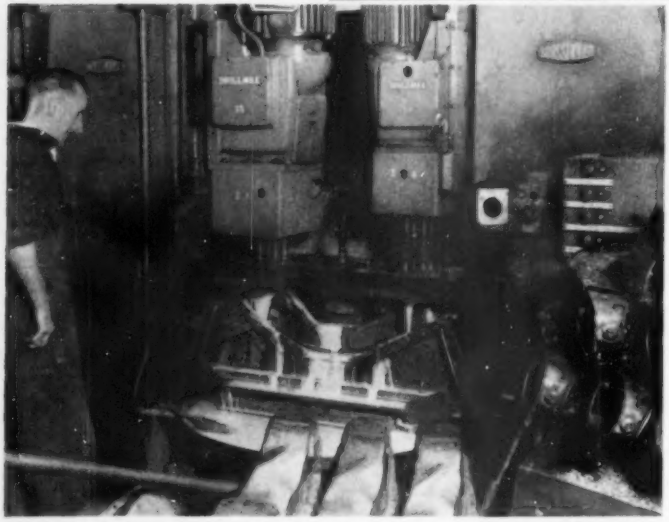


Fig. 22 (below).—Drilling and tapping M.G.A. front-suspension member on Brasshouse Drillmax equipment

of smaller complicated components. This type of member is required to be exceptionally rigid and dimensionally accurate, and usually comprises a deep pressing with solid-drawn ends to receive the helical spring mounting assembly.

The material used is pickled and oiled mild-steel sheet of extra-deep-drawing quality, the tensile strength being about 18 tons per sq. in.; the prime requisites of the material are high ductility and high surface quality.

Fig. 21 shows the first six stages in the production of the M.G member. The shaped blank is annealed after the blanking operation and then follow four pressing operations and a final crop, pierce, and side pierce operation.

The pressing is then jigged and strengthening plates for the wishbone locations spot welded on. A bottom plate is spot welded onto the flanges and small plates spot welded to the inside ends of the member.

The bottom plate is finally arc welded at certain points for additional strength, following which the assembly is passed to a checking and setting fixture.

The base holes for the bottom wishbones, 6 holes at each end, are then jig drilled and top hole drilling and tapping follows. The machine used for this operation incorporates four Brasshouse Drillmax heads (Fig. 22) two heads being used for drilling and two for tapping. The jig holding the suspension member is rotatable to allow the two sets of operations to be effected without removing the member from the jig. After cleaning up welds, etc., the assembly is passed to a final checking fixture.

(*Series to be continued*)

PRESS TOOLS
Their Design and Essential Characteristics

By J. A. GRAINGER, A.M.I.Mech.E., M.I.Prod.E., A.M.B.I.M.*

(This is one of a series of lectures presented at the Wolverhampton and Staffordshire College of Technology under the general title of "The Technology of Deep Drawing and Pressing")

IT is not the author's intention to attempt to cover every aspect of press-tool design; rather some of the less orthodox types of tool and their application, will be considered, first of all dealing as briefly as possible with some of the more common tools so that it will be possible to trace the use of the basic principles in the more unorthodox types of tool.

An example of this survey of basic principles will be found in that commonest of all operations—blanking. This operation is looked upon by too many pressworkers and tool designers as one of little consequence, and to them it is "just knocking a piece out of a strip of metal"; it is surprising how little many people know of what is necessary to make a successful blanking tool.

BLANKING, ETC.

Necessity for Accurately Maintained Presses

The individual function of, and interdependence of, presses and press tools should be clearly understood. A press is a piece of mechanism whose function it is to impart the necessary motions of a press tool. A press tool is designed for the express purpose of carrying out the actual work upon the piece of metal.

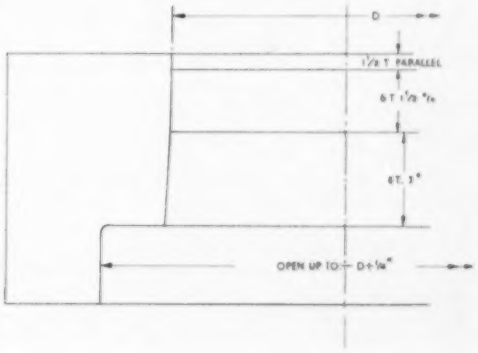
An accurately-made tool requires accuracy of operation and therefore it is essential that the press not only imparts motion to the tools, but imparts that motion in the required direction with extreme accuracy in the path of travel.

All press shops do not have the advantage of long runs on a mass-production basis; many are engaged on batch or short-run production. What is usually termed an "open-type" of tool is very largely used in these cases; that is to say a tool consisting of a punch-die and stripper—without guide pillars and bushings or leader pins. It will be at once apparent that the alignment of this type of tool is as accurate only as the press in which the tools are mounted. Excessive play in the ram guides will result in the punch striking the metal in a different place at almost every stroke of the press. This soon results in a "thrown" punch and blanks with an excessive "burr." A further result of badly maintained machine guideways will be a considerable increase in punch breakages—particularly when piercing holes whose diameter is little more than the thickness of the material. It follows therefore that press tools depend upon the accuracy of the machine in order to maintain their fullest efficiency and that good tool design and an accurately maintained machine are interdependent.

Cutting Clearance and Die Clearance

Two of the most important requirements in blanking or piercing tools are correct cutting clearance and correct die clearance. Lack of attention to these two items can seriously impair the life of the tools and the quality of the product. By cutting clearance is meant the actual amount of space between the punch and the die, and by die clearance is meant the amount (and shape) of the backing off beneath the cutting edge of the die. Insufficient or inaccurate die clearance may result in either distorted blanks, a burst die, or both. A form of die clearance which has proved very satisfactory in practice is shown in Fig. 1.

Fig. 1.—Die clearances



* Roneo Ltd.

This form of die clearance ensures accurate products with a reasonably long die life even on non-metallic materials such as Bakelite and synthetic resins with linen or paper base. The more common practice, however, is to use a 1½- to 2-deg. relief angle straight from the land portion of the die, and only to open out at the back of the die according to the whim or fancy of the toolmaker. By the use of this more common method the product from the die begins to lose its accuracy more rapidly than the method illustrated.

Control of Product Size

Press tools devoted to cutting operations have two functions. First, where the piece cut out is the required product *i.e.* blanking, and second, where the part from which the second piece is cut is the product, *i.e.* piercing. In each case the accuracy is a result of one member of the tool. Blank accuracy depends upon the die size and piercing accuracy depends upon the punch size. From this it will be obvious that cutting clearance must be carefully considered. For blanking, the die must be the member made to size, cutting clearances being allowed on the punch, which will be smaller than the size of the required blank. For piercing, the punch must be the member held to size while the cutting clearance will be allowed on the die which will be larger than the size of the pierced hole.

Where products of extreme accuracy are required an allowance must be made for the alteration in size which takes place on stripping due to the elastic recovery in the grain structure of the material adjacent to the cut edge. This allowance will vary with the type and temper of the material but, in general, will be about 1 per cent of the thickness, *i.e.* minus on a blank size and plus on a piercing size.

It may be of interest at this point to mention the production of blanks for impact extrusion.

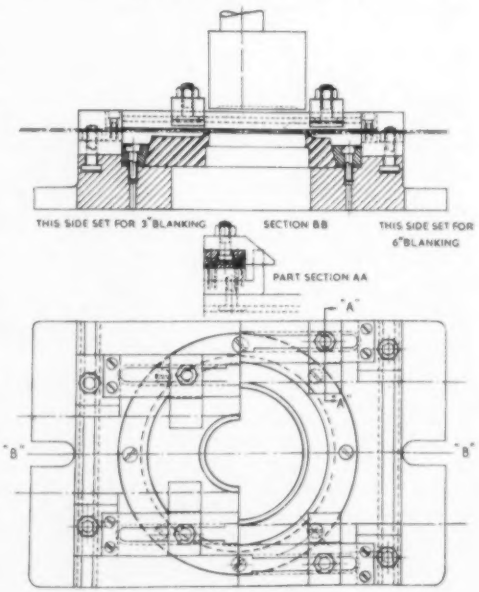
When a hole is punched in a piece of metal, the cut does not extend through the whole thickness but is only through the first one-third of the thickness; the remaining two-thirds being merely the break-through of the metal after shear. This break will appear as a serious blemish on the walls of the extruded tube. Therefore to avoid an expensive shaving operation on the slugs, a different blanking technique has to be adopted. There are two methods in use, one in this country and one on the Continent. Both are evolved on the same basic principle, pinch blanking. In this country the pinch is made by a tight fitting punch in a die having a radiused edge instead of a cutting edge. The radius has, in every case, to be developed to suit the type and thickness of metal being used and is extremely critical, a few thousandths of an inch making the difference between success or failure. Research and investigation is being carried out in order to establish a formula for this radius in order to avoid the necessity for continual development work.

On the Continent, the pinch is made against an angular die edge. The angle is usually equal to the thickness of the metal being used and is at 45 deg. In some cases however the angle may be much less than metal thickness. Thus for material ⅜ in. in thickness the die would have a maximum angle of ⅜ in. × 45 deg. Where the angle meets the die wall there is no perceptible radius, the sharp edge is merely broken by a minute radius of perhaps 0.010 in. or 0.015 in. With this Continental method there is one obvious drawback—the excessive scrap allowance between blanks.

Reverting to normal blanking and/or piercing, it is common sense to relate the type of tool to the quantities required in production. For small-quantity production a very simple, yet robust, tool will be sufficient without the provision of a die set or guide pins.

On the other hand, where extremely large production runs are necessary, a very different type of tool will be required. To maintain peak production there must be no danger of tool break-down during the run. To ensure this the punch and die units should be mounted in a die set of accurate and robust manufacture. Backing off and clearances must be given careful consideration as previously explained, and, in addition, strippers will need to be designed in such a way as to be efficient

Fig. 2.—Standardized blanking tool with adjustable stock guides and stripping fingers



in operation, give support to any slender punches, but not interfere with the passage of the material through the tools or hinder the view of the operator. As, in these cases of extremely high production, the tools are frequently used in presses fitted with some form of mechanical feed it will be necessary to provide a feed stop against which to feed the strip for the first stroke of the press. No matter how great the quantities of parts required, sight must not be lost of one prime essential—all press tools must combine efficiency with simplicity of construction. Do not design complicated tools for just the sake of showing off one's inventive flare or ingenuity.

Standardized Blanking Tools

Standardized tools for blanking are frequently used for the production of circular blanks for feeding to drawing presses in order to economize on tool costs and material usage. In such cases the standard unit is the bolster into which is built some arrangement of adjustable stock guides and stripper fingers. Such a standardized type of blanking tool is illustrated in Fig. 2.

It will be seen that changing of the die rings is extremely easy as also is the adjustment of the guides and strippers.

BENDING AND FORMING

Factors Influencing Bending

Bending and forming probably rank next to blanking and piercing as the commonest operations encountered in the press shop. Many of the foregoing remarks in respect to blanking also apply to the bending series of operations *i.e.* serious consideration should be given to production quantities in relation to the complexity of the tool. Certain other factors also enter into the problem. Some of these factors can be instanced *i.e.* variation in the material gauge, temper (or hardness) variations, direction of the grain of the material in relation to the bend line, the severity of the bend (or the intricacy of the form being imparted to the metal) etc.

One great temptation must be avoided, that of attempting too great a manipulation of the metal in a single stroke of the press.

Tools can vary from the very simple " Vee " bending tool to the most advanced cam and slide bending tools. As far as possible the aim should be for the greatest simplicity in the design of the tool. By keeping to the minimum the number of moving parts, and avoiding all unnecessary attachments, the troubles of the press shop will be greatly minimized. Each extra member in the tool calls for vigilance on the part of the press operator, extra care on the part of the toolsetter, and is a source of extra cost on the tool and its maintenance. Also a clear unobstructed view of the operation zone of the tool cannot be obtained resulting in a lowering of the safety standard.

Spring-back and Grain Run, etc.

Considerable trouble can be caused by what is known as " spring-back " or, to be technically correct, " elastic recovery," *i.e.* the natural tendency of the metal to return to its flat state. This varies with the temper of the material and therefore no set standard allowance can be stated by which the bend should be overset to allow of spring-back to the required angle of bend. The correct allowance can only be found by a combination of experience and patience during the die-proving period. The allowance will also vary in relation to the direction of bend, whether across the grain or parallel to it. It is a point to be considered seriously, whether the temper, combined with the direction of bend in relation to the grain run of the material, will permit a successful bending at all. It should be remembered that it is very difficult, if not impossible, to bend parallel to the grain in any temper above $\frac{1}{4}$-hard in steel unless the bend is only very slight. The result of attempting a light bend of 120-deg. inclusive angle in $\frac{1}{2}$-hard temper steel is shown in Fig. 3.

Do not design the first raising tool in a sequence of operations so near to the size of the final (or subsequent) operation that the re-striking tool is left with too small an amount of metal on which to " bite." To do so results in the product " springing " to the final tool and losing its size again on ejection.

Types of Bending Tool

The simplest form of bending tool is the " Vee " tool, which can be made to produce successful bends at any angle between about 20 deg. inclusive to approaching 180 deg. At the lower end of the scale, the smallest inclusive angle practicable is dictated by the gauge of the material, allied to the maximum thickness that can be allowed for the punch blade.

Apart from the locating of the blank, the only major consideration in this type of tool is the bend radius. It must be decided whether the radius at the corner is within the limit of safe bending in a single operation or whether a re-striking operation

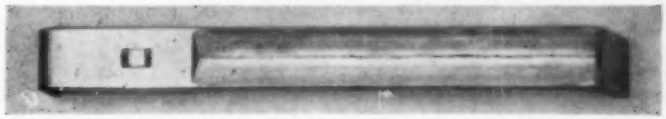


Fig 3.—Crack due to grain directionality

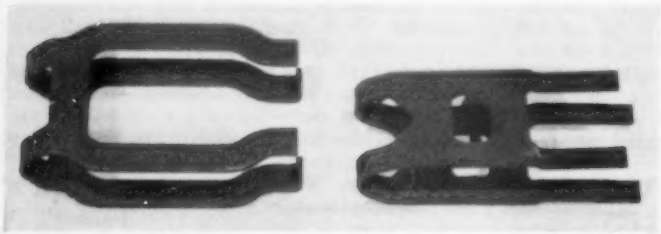


Fig. 4.—Deep bends without spring-back on short-stroke presses

is required to sharpen and set the corner. If it is assumed that a single operation is required the only other point for serious consideration is that of " spring-back " or elastic recovery. Spring-back is avoided if the grain structure of the point of bend can be " broken down " or " set " to its new form permanently. A " Vee " tool is the type in which this can most easily be accomplished. There are two methods:

(*a*) By putting a radius in the bottom of the " Vee " in the die and arranging the size of the apex of the punch to consolidate the grain structure of the material. (This is usually achieved by making the punch with a smaller inclusive angle than the die).

(*b*) By machining a groove along the whole length of the die at the bottom of the " Vee," so as to create a tendency to swage the metal into this groove, thus reproducing a similar effect as in the first method.

The product from the first method will be rather better in appearance than that from the second.

When products have to be bent in an out-of-balance form, for instance on two adjacent sides, it is advisable to bend two parts together, in order to balance the pressure and enable a " box " type of die to be employed. On a straightforward bend of this type the tool can be made to planish on the bottom of the stroke and eject the parts by means of either mechanical ejectors, worked from the ram, rubber buffers, or springs attached in a bank beneath the die shoe.

Considerations in the Design of Bending Tools

Before the design of the tools is begun, due consideration must be given to the fixing of the correct operation sequence in order to avoid major tool alterations after try-out.

The following points need to be borne in mind when fixing the sequence of operations:

(*a*) The accuracy required on the product.

(*b*) The material from which the product is to be made.

(*c*) The possibility of distortion of one or more bends by the succeeding operations.

(*d*) The possibility of the collapse of the tool due to weak construction through combining too many operations at one and the same time.

(*e*) The ease of loading and unloading the tools.

(*f*) The quantities required, both in total and per manufacturing batch.

(*g*) Last (but not least) the reactions of the shop-floor personnel when they come to use the tool for production.

The items at *a*, *b*, *c* and *d* will decide the number of operations required and *e*, *f* and *g* will dictate the nature and simplicity of the design. Assuming that a bent and formed part embraces several bends, and of these bends three have to be held to fine limits while the others are of less accuracy, then if any doubt should arise that distortion may take place, common sense suggests that the sequence should be planned in such a way that any possible error will be thrown on to the portions of least accuracy. In a case where extreme accuracy is required on all parts of the product, but distortion greater than the allowable limits is inevitable during the sequence, then there must be a final operation for re-striking all faces simultaneously.

Both of the products shown in Fig. 4 were each bent at one operation on short-stroke presses (3-in. stroke) with toggle folding tools and were planished

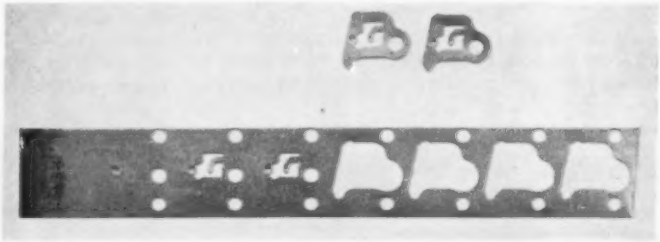


Fig. 5.—Strip of material after progressing through the tools shown in Fig. 6. Above the strip is shown the product after blanking from the strip stock

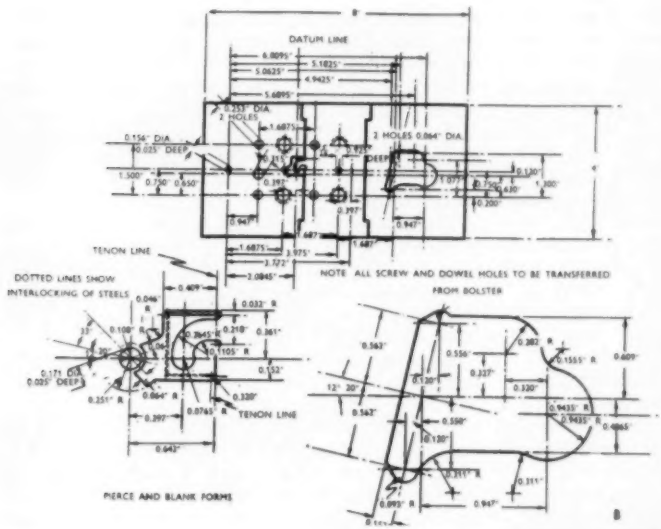
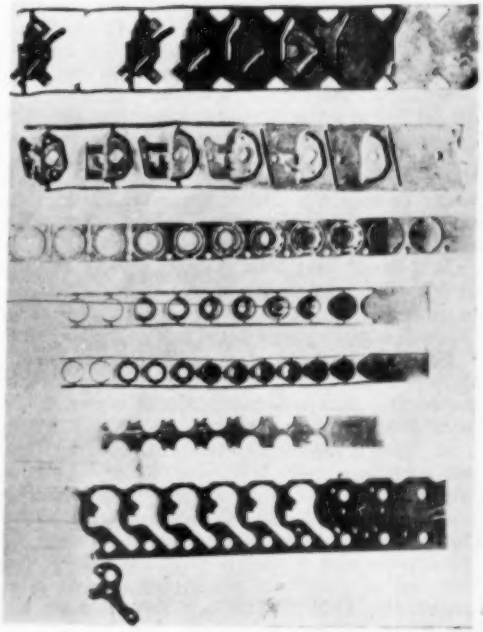

DATUM LINE
TENON LINE
DOTTED LINES SHOW INTERLOCKING OF STEELS
NOTE ALL SCREW AND DOWEL HOLES TO BE TRANSFERRED FROM BOLSTER
PIERCE AND BLANK FORMS
TENON LINE

Fig. 6 (left).—Layout of die face for product shown in Fig. 5

Fig. 7 (below).—Examples of follow-on work



on all faces at the bottom of the stroke, in order to attain the required standard of accuracy. The "Vee" angle at the closed end was required within plus or minus 1 deg. and the legs were to be held parallel within 0.010 in. Both these conditions were maintained in quantity production.

Follow-on Tools

If many operations have to be performed on a product that is to be made in large quantities, it is not advisable to try to compound too many of them into a single stroke of the press. Far better results will be obtained by building a tool of the multi-stage follow-on type. The tendency is to use this method of tooling to full advantage and modern tools combine practically all types of operation normally met with in any press shop. As many as fourteen or more stages being combined in some present-day tools.

As with other methods of tooling, each product has to be studied on its own merits, and, if there is a sequence of fairly intricate stages in the tool, each stage must be considered in the light of its own individual problems. Naturally the problems vary in magnitude, but not in the same magnitude as the number of stages in the tool. A tool of, say, only two or three stages (each of which is complicated) will present problems far greater than a tool of six (or even eight) easy and straightforward stages.

Die Construction

In a large progressive follow-on tool it is good practice to build up the die in sections so that machining of the die forms is made easier. This will assist in tool repair and maintenance. When laying out these sections of the die, particular notice should be taken of the shape of the die aperture, and the parting line should be arranged to give the greatest strength to each steeling even should it mean laying out the parting line at an angle across the die face. Thus if there should be an angular side to the die aperture at the point

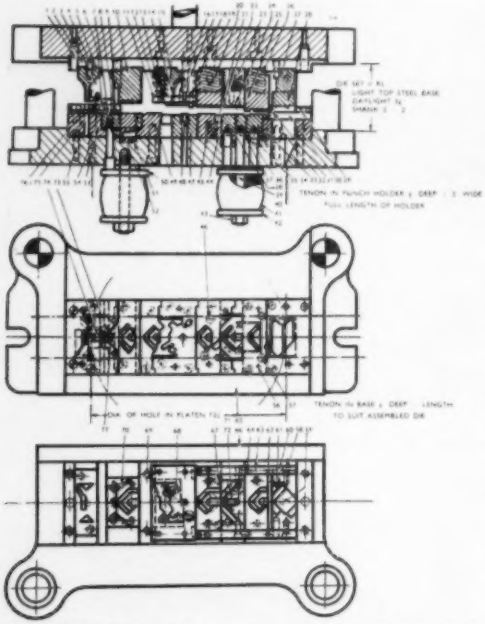


Fig. 8.—Follow-on tools for a component the strip from which is shown at the top of Fig. 7

where it was decided to place the parting line, it would be rather foolish to place the parting line square with the centre-line as an acute angle would be left on the steeling.

This would have little strength and break early in use. The parting line should be at right-angles to the side of the die aperture, or from one corner (but still at right-angles to the side of the aperture).

Fig. 5 illustrates a strip of metal after passing through a follow-on die on which careful placing of the parting lines was required with regard to the peculiar shaped piercing.

In Fig. 6 is shown the layout of the die face from which can be seen the method of placing the parting lines. Apart from the designer, the toolmaker must be wide awake when reading a drawing for a die such as this; for it is all too easy to misinterpret the drawing and so machine with a straight parting line and so result in the curved portion being destroyed. This did, in fact, happen when this particular die was first made, and the one die section was scrapped and had to be remade. With built-up dies it is always advisable to tenon the blocks into the bolster, and also to one another, in such a way as to counteract any bursting tendency due to the force of cutting. This bursting strain can act in two ways, first it has the effect of attempting to force the die blocks apart at the joint face, and, second, there is a sideways force which tends to move the segments or blocks out of line with each other. It is unsafe to rely on dowels to prevent this movement, tenoning is the only reliable means.

Some examples of strips taken from multi-stage follow-on tools are shown in Fig. 7.

As will be visualized the dies for the two upper strips presented quite a few design problems and included many features that have been discussed so far.

The follow-on tool for the first of these two parts is shown in Fig. 8. The placing of the parting lines for the various sections, and the method of tenoning the segments to one another and into the die bolster are clear, and serve to illustrate the interlocking effect to prevent movement.

Included in the sequence were the following operations: piercing, notching, raising, lancing, extruding and forming. This tool is designed for hand feeding and is fitted with a spring-loaded toe stop which engages with a pierced slot.

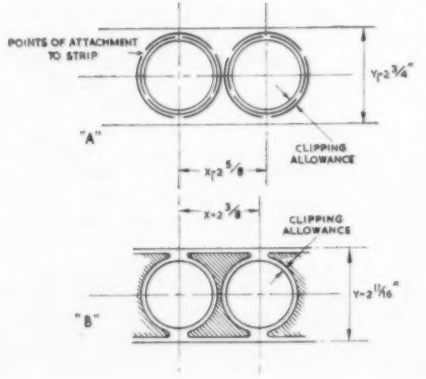
Many follow-on dies include drawing and very deep forming in the sequence. In these cases particular care must be taken to ensure unobstructed feeding. To do this the strip should be traversed across a flat die face. There is only one satisfactory way of doing this, and that is to draw the metal upwards into hollow punches. The draw pummels are placed in the die plate and a floater plate surrounds them, being raised slightly above their level so as to present a flat face over which the strip can travel. Blank-holding pressure is applied to this plate by means of a small pneumatic cushion, or a rubber buffer.

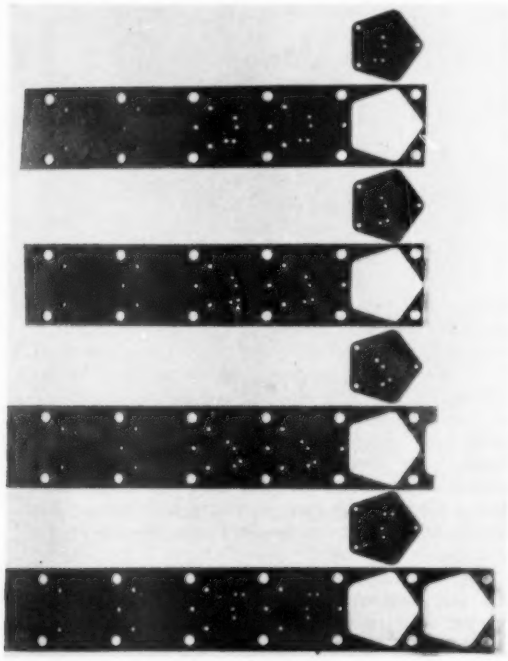
Relief of Strip

Notching of the strip to facilitate drawing must also be given proper consideration.

Fig. 9 shows two of the commonest and most efficient methods used in general practice. From

Fig. 9.—Comparison of different methods of relieving the strip when drawing operations are included in a follow-on sequence





this illustration it will be seen that material economies also become considerations for the tool designer when dealing with high production, particularly in non-ferrous metals.

Double Die-set Tool

The tool designer must also be prepared to consider the problems of tool cost and production volume.

In order to illustrate this point a case from actual practice can be considered.

Shown in Fig. 10 are four strips of material, and the products from them, after passing through the same follow-on tool. At first sight the products appear to be the same, but closer inspection will reveal that the four small pierced holes in the middle are in different angular relationship to the outside pentagonal form.

As there would be many thousands of each to make, and they would need to have an identification mark on them, there appeared to be two alternatives:

(*a*) Make a follow-on tool for each part, or,

(*b*) Make a follow-on tool to pierce the three large holes and blank only, afterwards piercing the four small holes as a separate operation.

Eventually neither of these alternatives was adopted; a third presented itself and proved to be the solution to the whole problem, tool costs were kept at a minimum and production rates were held at maximum by using a single tool for all.

The tool is shown in the drawing, Fig. 11, and has an unusual feature inasmuch as it comprises a die-set within a die-set; the inner die-set is arranged to index into the desired position for whichever part was required. In doing so the correct marking punch for identifying the part also rose into the operating position while the others retracted. By this means the tool could be changed from one product to another without even removing it from the press, or even altering the ram adjustment.

In recent years there has been much development —and publicity—of the transfer press as a challenger to the multi-stage follow-on tool used in double roll-feed presses. It is not possible to give a lengthy discussion on these presses and their tooling, however, it must be made clear that these machines and tools are ideal where applicable but,

Fig. 10 *(above).—Strips, and products, after passing through the tools shown in Fig.* 11, *one from each of its four index positions*

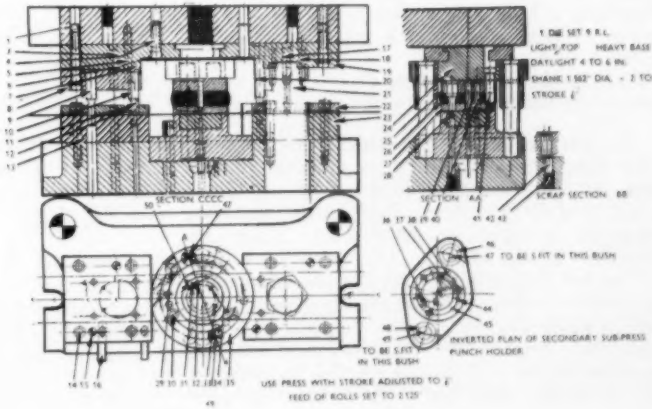

SECTION CCCC
SECTION AA
SCRAP SECTION BB
47 TO BE S.FIT IN THIS BUSH
INVERTED PLAN OF SECONDARY SUB-PRESS PUNCH HOLDER
TO BE S.FIT IN THIS BUSH
USE PRESS WITH STROKE ADJUSTED TO
FEED OF ROLLS SET TO 2.125"

Fig. 11 *(right).—Double die-set tool for components shown in Fig.* 10

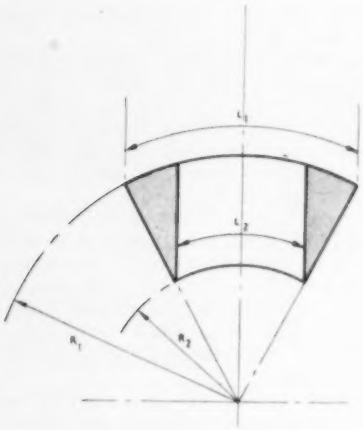


Fig. 12.—Diagram illustrating why blankholder pressure is necessary

owing to their great cost, the question of economics of production becomes probably the greatest factor to be considered when making a choice.

THE DRAWING OF SHEET METAL.

The Need for Blankholding Pressure

It is well-known that blankholding pressure is required when deep drawing, but why ?

In an attempt to explain this, Fig. 12 shows a sector from a round blank in position over the die preparatory to drawing. If R_1 is the radius of the blank and R_2 the radius of the die opening, it will be appreciated that the arc L_1 in its journey over the die face will reduce in length to arc L_2.

Under these conditions the material shown shaded will have to be displaced. The displacement can only take place by a compressive action which causes a hoop compressive stress in the annular rim outside the die mouth. If no means of controlling this hoop compressive stress is brought to bear wrinkling will occur in the metal as shown in Fig. 13.

The blankholder on a deep-drawing tool is the means of controlling this hoop compressive stress.

Theories for First-operation Draw Faces

On first-operation drawing the die face can, and does, exercise a very great influence on the success or failure of the operation. Two theories have been expressed in regard to draw faces. These are illustrated in Fig. 14.

The first theory states that the die face should be slightly hollow, and the second says that the die should be slightly conical. Curious as it may seem these two theories are advanced as measures to offset the same happening *i.e.* the thickening of the rim of the blank due to the hoop compressive

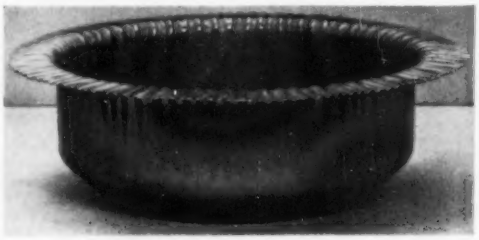


Fig. 13.—Wrinkling due to low blankholder pressure

stress as it travels over the die face. Of these two theories, the first is the only one that, to the author's knowledge, has been put to practical use, and even then only on comparatively small blanks of non-ferrous metal. The amount of the " hollowness " too has been much less than called for in the theory, being only about 0.002 in. on a die for a 2-in. dia. blank. For severe drawing operations on steel neither of these two die faces have proved practical and a dead flat die face matching with a dead flat blankholder has been found to be the only true solution.

Fig. 15 shows the result of using perfectly flat die and pressure plate faces, and represents a 55 per cent reduction in diameter from a 15-in. dia. blank in a single draw.

Second-operation Draw Edges

The foregoing consideration of stresses must be also extended to redrawing operations, and will determine the shape of the " draw edge," for it will be appreciated that there is no " face " on a re-drawing die.

Fig. 16 shows typical drawing tools for 1st- and 2nd-operation drawing. Referring to the dies for the re-drawing operation it will be noticed that two forms of die edge are shown. As will be realized, one of these is correct and one is incorrect

Fig. 14.—Explanation of draw faces

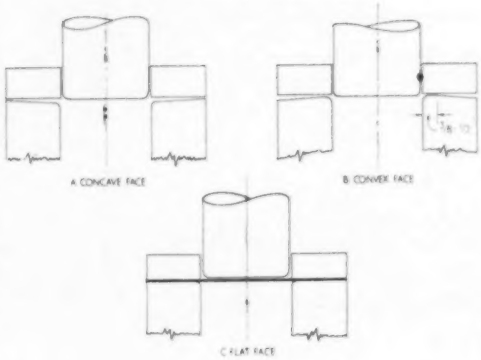


Fig. 15.—A particularly severe single drawing operation performed on dies with flat draw faces in a double-action press. (A 55 per cent reduction on a blank 15-in. dia.)

or, one is much more efficient than the other. The incorrect one, particularly for exceptionally severe redrawing operations is that with the two radii and a slight flat in between. Why is this incorrect ? In this case the cup from the first draw would have merely a radius on the bottom corner and would therefore sit on the flat face in the depression machined to locate it. On the descent of the blankholder, therefore, the bottom of the cup is gripped between the faces of the die and blankholder.

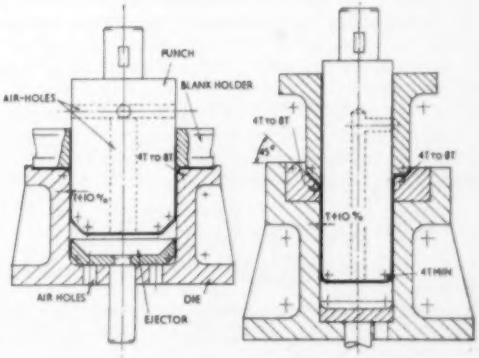
Next, on the descent of the drawing punch, the metal is drawn between these two faces and into the die mouth. On its journey the metal makes two abrupt changes in the direction of travel with a pause to traverse in the flat plane between. Each sudden change in form means that extra work-hardening is taking place with a consequent loss of ductility of material. This in turn means that extra power is needed to complete the change in form under these conditions. From this the logical deduction is that the die form should be designed in such a manner as to assist the metal to flow into the die mouth with no sudden or severe change in form or direction.

By using an angular edge (if the included angle does not exceed 90 deg.), the path that the metal follows into the die mouth approximates more closely to a straight line (particularly as the included angle decreases for thicker material), and what is particularly important, there is no sudden and complete change in the direction of travel; the change is gradual throughout the full cycle.

As the thickness of the material under manipulation increases, so the necessity for the use of an internal blankholder decreases until the point is reached where this blankholder may be dispensed with entirely. The reason that this is so is given by the fact that in re-drawing operations, as well as in the first drawing operations, stresses are set up in the metal; or perhaps it would be more correct to say that existing stresses are increased. These stresses are again compressive stresses and are set up in the first instance in that portion of the product that is between the blankholder sleeve and the draw edge of die. When thin material is being drawn these hoop compressive stresses very easily cause wrinkles to form in this portion of the product, which then spread rapidly into the parallel wall of the product; therefore, an internal-sleeve-type blankholder is necessary to restrain these wrinkles. As the thickness of the material being used increases, however, the opposition to the formation of wrinkles also increases very rapidly—this being due to the greatly increased area, which is presented to the force tending to cause distortion, and therefore able to withstand a much greater compressive stress. Providing, therefore, that due consideration is given to all the factors influencing the drawing cycle for any given reduction in diameter, and that the draw edge is designed to minimize the amount of stress, the condition may be created where the material will have sufficient resistance to the stresses and so enable the blankholder to be dispensed with entirely. The result of attention to the aspects of re-drawing, as mentioned above, is shown in Fig. 17.

Only one blankholder was used in the sequence of drawing operations for this product *i.e.* on the first drawing operation. All other operations were performed without the use of internal blankholding sleeves.

Fig. 16.—Illustrating the essential features of first- and second-operation draw tools



REVERSE DRAWING

A combination of theory, practice, and applied science can achieve remarkable results in the sphere of deep drawing. This combination is particularly called for when embarking upon the type of deep drawing known as " reverse drawing " a technique which has up to now been sadly neglected. What actually is reverse drawing ? It is simply taking a drawn cup, or shell, from one drawing operation and turning it inside out in another. It has been proved that the employment of this technique enables greater percentage reductions in diameter to be made, and also reduces or eliminates the necessity for that undesirable operation, interstage annealing.

Stress Equalization by Reverse Drawing

Why should reverse drawing enable extraordinary reductions to be made ? Consider a cup that is drawn, re-drawn and again re-drawn, perhaps through several operations. What actually happens to the metal during the repeated process of drawing down to a smaller diameter and greater length ? The material has stresses set up internally during the first drawing operation, and these stresses are progressively increased at each succeeding drawing operation. As the material at the inside of the cup is on a smaller diameter than that on the outside of the cup, it is quite logical to reason that the stress is not uniform throughout the thickness, but varies in intensity, being greater at the inner surface than at the outer surface. Therefore, as re-drawing proceeds, the stress at each face of the metal is increased, but the stress in the inside surface of the metal is always the greater and is continually being increased; the greater the number of operations, the greater will be the difference between the stresses on the opposite sides of the metal until stress cracking occurs.

When using the reverse drawing technique, however, this same reasoning does not apply. As the material is reversed at each reverse drawing operation, the diameter of the cup which was largest (the outside) becomes the smallest (the inside). As this reversal of relationship of the diameter takes place, is it not safe to assume that the same thing happens with the resultant internal stresses in the metal itself ? The surface of the metal which was the most highly stressed (the inside) becomes the least highly stressed (the outside). By thus continually reversing the stresses in the material and obtaining more consistent cold working, it is suggested, the reverse drawing process achieves those severe reductions without interstage annealing, for, after all, annealing is instituted mainly as a means of stress relief and to restore

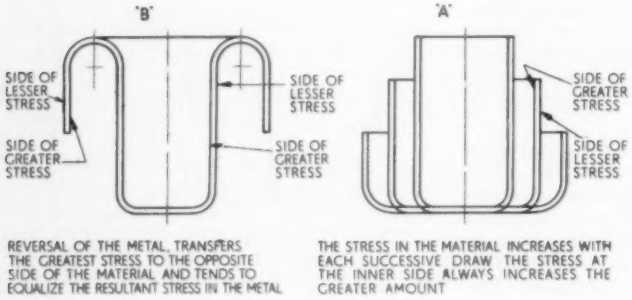

"B"
SIDE OF LESSER STRESS
SIDE OF GREATER STRESS
SIDE OF LESSER STRESS
SIDE OF GREATER STRESS
REVERSAL OF THE METAL TRANSFERS THE GREATEST STRESS TO THE OPPOSITE SIDE OF THE MATERIAL AND TENDS TO EQUALIZE THE RESULTANT STRESS IN THE METAL
"A"
SIDE OF GREATER STRESS
SIDE OF LESSER STRESS
THE STRESS IN THE MATERIAL INCREASES WITH EACH SUCCESSIVE DRAW THE STRESS AT THE INNER SIDE ALWAYS INCREASES THE GREATER AMOUNT

Fig. 17 *(above).—The four drawing operations required to produce a steel shell shown on the extreme right, without interstage annealing. Blankholder used on* 1*st draw only. Stripping sleeves used on* 2*nd,* 3*rd and* 4*th draws. Material* 0.080*-in.* (13*-s.w.g.*) *D.D.M.S.*

Fig. 18 *(left).—Diagram of direct drawing "A" and reverse draw "B" to explain the theory of stress equalization*

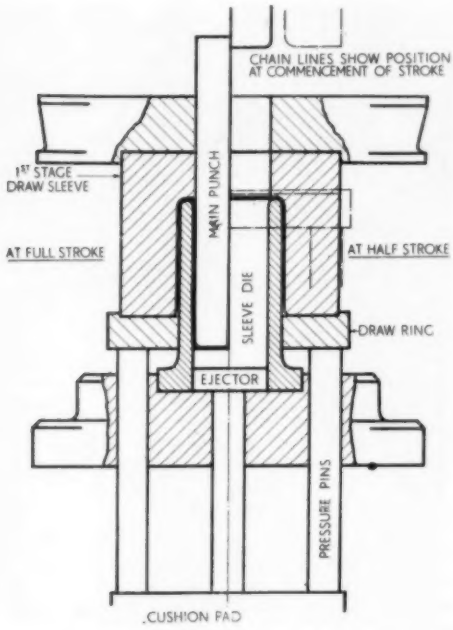


Fig. 19.—Triple-action reverse draw tool

Fig. 20.—Drawn in one operation (from blank shown)

ductility to the material. This stress reversal is depicted diagrammatically in Fig. 18.

Compound Reverse Drawing

It was conceived that if both first- and second-drawing operations could be combined in a single stroke of the press, thus eliminating even the slightest pause in which age-hardening could possibly take place, it would be feasible to produce an extremely deep tube in one drawing operation. To test this theory a product was selected and percentage reductions on diameter were fixed and press loading calculated. As, with the type of tool visualized, it would be necessary to use a double-action press equipped with a pneumatic cushion, to perform the dual drawing operation, these calculations obviously were extended to ascertain what load would be transmitted through the toggles on to the actuating cams of the crankshaft. The load at this point was estimated to be 4 tons on each cam, or an addition to the drawing load of 8 tons—this becoming operative before the main drawing load was imposed on the ram and thence to the crankshaft.

To avoid undue spoilation of the shaft, precautions were taken in the form of high-pressure force-feed lubrication to the shaft, connecting rod, toggle links and cam following rollers. To withstand the higher crushing load that would be imposed, the existing bronze bushings in the rollers were replaced with nickel-cast-iron bushings.

The type of tool developed is shown diagrammatically in the drawing in Fig. 19.

The photograph in the following illustration, Fig. 20, shows the blank and a finished drawn tube produced by this method.

The next two illustrations, Figs. 21 and 22, show the tools mounted in the press.

The drawn product is 2.312 in. in diameter and $4\frac{1}{2}$ in. in length and is produced from a blank $6\frac{5}{8}$ in. in diameter by 0.034 in. in thickness.

It has been established that for the initial draw, against the cushion, the normal die clearance is quite inadequate; a clearance applicable to this technique is $22\frac{1}{2}$ per cent above metal thickness, *all round the die, i.e.* for metal 0.034 in. thick, the diameter of the female member, *i.e.* the blankholder acting as a die, should be 0.0832 in. larger than the male member, *i.e.* the lower die acting as a punch. For the final stage of the draw, the normal clearance of 5 per cent above metal thickness is quite satisfactory.

CALCULATION OF PRESS SIZE

Tonnage to Cause Plastic Flow

It is not realized by all tool designers that the power required to perform a deep-drawing operation can be calculated just as easily as that required for a blanking or piercing operation.

Fig. 21.—Tools for product in Fig. 20, in press. Pressure plate at commencement of stroke

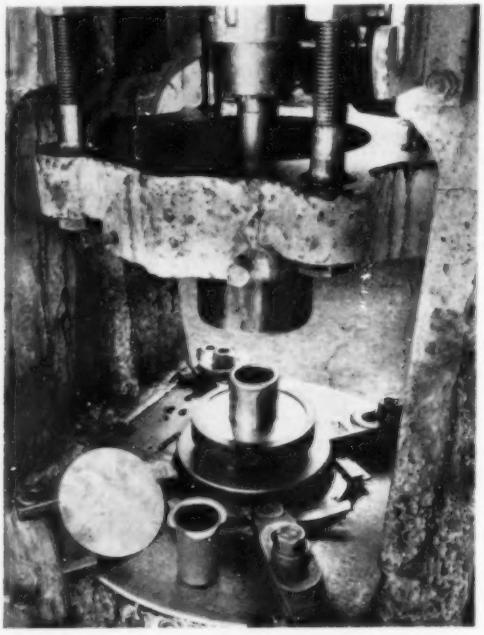


Fig. 22.—Same tools as Fig. 21. Pressure plate in position at bottom of stroke

A double-action press need not therefore be chosen on bed area and stroke alone, although these do enter into the picture as will be seen a little later.

Just as a blanking load is calculated from the shear strength of the material, so the drawing load is calculated from the plastic range of the material. As any metal must be strained beyond its yield point to assume permanent deformation the solution becomes clear. For all practical purposes it can be assumed that the critical point for plastic flow is midway between the yield point and the ultimate tensile stress.

Therefore, to cause plastic flow in the material a pressure must be attained equal to the yield plus the U.T.S. divided by 2. So to find the total pressure required the figure thus obtained, in tons per square inch, is multiplied by the cross-sectional area of the wall of the cup in square inches. This then will give the tonnage required at the point of impact with the material and may be written as:

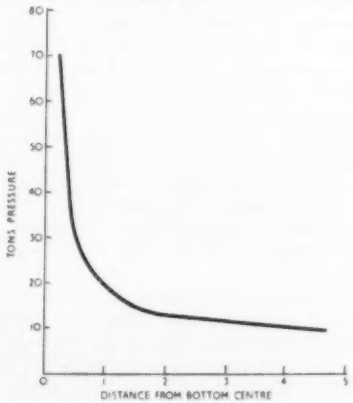
$$\frac{\text{Yield} + \text{U.T.S.}}{2} \times \text{Cup Wall Area}$$

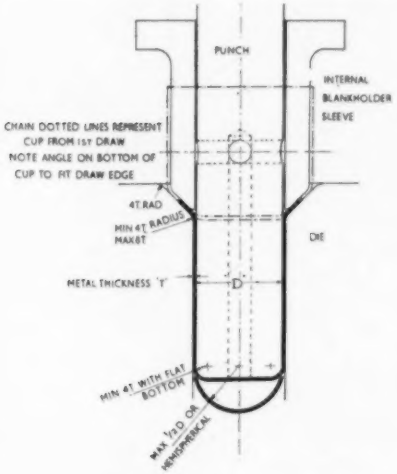
Loss of Power at Midstroke

It will be noted that the tonnage required was stated to be at the point of impact with the material. When designing tools for use in mechanical double-action presses this has an important bearing on the size of press required (tonnage rating).

Practically all press makers give the capacity of their presses in tons available "at or near to the bottom of the stroke." If consideration is given to the conditions prevailing in a mechanical crank-operated power press, it will be at once obvious

Fig. 23.—Graph showing loss of power at mid-stroke on a crank press



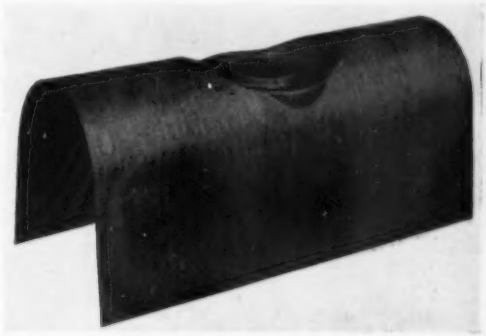


that the power available is not constant throughout the stroke.

Fig. 23 gives some indication of how power available reduces rapidly at points other than on bottom dead centre. This of course is due to the torque on the shaft, applied by the crank webs as a result of the resistance of the metal to deformation. Power available can be as low as only 25 per cent of full power should the point of impact be near to midstroke.

How Size of Press is Governed by Depth of Draw

Fig. 24 will help to explain how the depth of draw influences the choice of press for the particular product. The stroke of press required will be equal to: twice the depth of draw beyond the draw



edge + depth of draw edge + a minimum of 2 in. for lift-out clearance. (This latter dimension will also be needed to satisfy safety requirements).

Therefore assuming the product to be 8 in. deep from the draw radius, and the draw edge angle to be 1½ in. deep, the stroke of press required will be 20 in. say a standard 24-in. stroke press. The punch will meet the material at 9½ in. above bottom dead centre—or practically midstroke—where power available is only about 25 per cent of total.

Assuming that the total pressure required to cause plastic flow is 50 tons (this is the figure for the article being considered), the size of press required will be 200 tons minimum capacity with a stroke of 24 in.

USING THE DOUBLE-ACTION PRESS FOR COMPOUND WORK

Much more could be written about difficulties to be overcome, and considerations to be given when designing press tools.

(*Continued in page* 765)

Fig. 24 (top left).—How depth of draw governs point of impact of punch with metal

Fig. 25 (top right).—An interesting multiple operation double-action press job

Fig. 26 (right).—Tools for producing part shown in Fig. 25

HEAT TREATMENT OF THIN ALUMINIUM SHEET FACILITATED BY THE USE OF SPACER SPRINGS

Fig. 1.—Spacer springs being inserted at the top and bottom of a coiled thin-gauge aluminium sheet

TO facilitate the heat treatment of thin-gauge aluminium sheet that would not otherwise remain in position for such treatment, a new technique, utilizing spacer springs of die steel, has been evolved by manufacturing research engineers of the Aero-Space Division of the Boeing Airplane Company, Seattle, Washington, U.S.A.

Eliminating heat-treatment distortion in aluminium sheets ten to sixty thousandths of an inch thick, has always been a troublesome problem in the aircraft industry. General-purpose aluminium heat-treatment furnaces, in which the sheets are processed to the strength and durability necessary for high-performance aircraft, usually have heavy-bottomed racks of steel mesh and structural members. When the racks, with sheets suspended by overhead clamps, were plunged into the cold water quenching bath, their bulk created a turbulence that often warped thin sheets and tore them from their supports.

An initial attempt to overcome this difficulty involved the coiling of the sheets and loading them upright on the racks. When this was done, some highly-stressed sheets uncoiled during heat treatment causing whip-lash damage and subsequent warpage, or metal-to-metal contact that caused weak spots. If the coils were tied or clamped, again there was metal-to-metal contact as the coil was compressed. Uniform heat transfer was impeded, proper flow of quench water was interrupted and lowered mechanical properties and warpage frequently resulted.

In order to restrain the coiled sheets and, at the same time, prevent metal-to-metal contact, the Boeing engineers responsible for the investigations developed special spacer springs of H11 die steel which were inserted at the top and bottom of the coiled sheet, the springs being first stretched to facilitate coil placement and tension being later released to fix the coil firmly in position.

The best spring size for handling the aluminium sheets was found to be 8 in. in length and 1 in. outside diameter, of 0.063-in. wire. Extensive tests in production furnaces proved that the springs retained their tension through several hundred heat treatment cycles.

After several months of production use, the spacer springs have now become established at Boeing as fully satisfactory in respect of ease of application, economical handling and reliability. They hold the coiled aluminium sheets firmly in position on the heat-treatment racks with space between the coils that ensures uniform heat distribution and quench water circulation, resulting in improved quality and fewer rejections.

An Investigation of Swift Cupping Test Correlation and the Influence of Tool and Material Surface Finish on the Test Results

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and D. R. MEAR, B.Sc., A.M.I.Mech.E.*

(A paper presented at the recent joint meeting in Paris of the International Deep Drawing Research Group and the Societé Française de Metallurgie)

SUMMARY

RESULTS for the Limiting Drawing Ratio in Swift cupping tests (50-mm. punch) performed on three independent presses for rimming and stabilized steel, 70/30 brass and aluminium are presented. The degree of control over testing conditions and procedure necessary to ensure good correlation is described. It was found that of the three materials examined aluminium imposed the strictest conditions and an increment in blank size of 1.25 mm. (0.049 in.) in determining Limiting Drawing Ratio appears to be too highly discriminating for this metal.

The factor which was found to be most difficult to control was punch and die surface quality, so an investigation was carried out to determine its influence. Results are quoted for various combinations of surface roughness on punch, die and materials within the limits 0 to 20 micro-inches, centre-line average. Recommendations, especially in relation to working surfaces, are given for defining tool surface roughness in carrying out such cupping tests.

Introduction

THERE is interest in several European countries in establishing a standard cup-forming test which would give a reliable measure of the drawability of metal sheet and strip. It is not feasible to expect that any one test could be devised which would simulate the straining conditions of all drawing operations encountered in practice but it may be found possible to specify minimum requirements for sheet and strip for certain operations. On an international basis a standard test would allow research work to be more easily compared and the results confidently assessed from known parameters. In 1957, Kemmis[1] published a procedure for carrying out the "Swift" cupping test and this procedure with certain modifications is the subject of current discussion and examination by member countries of the International Deep Drawing Research Group.

In this paper results of the Swift test on rimming and stabilized steel, 70/30 brass and aluminium on more than one press are presented to permit examination of correlation between presses. A further investigation was then made of the influence of tool and metal surface quality on the Limiting Drawing Ratio.†

Prior to and during the correlation trials elaborate precautions were taken in an attempt to eliminate anticipated causes of variation in testing procedures. Mostly the procedure of Kemmis[1] was adopted but a few additions and alterations were made to ensure the closest agreement possible. Full details are given hereafter of the test conditions and techniques used.

I.—Correlation Trials

Materials Tested

Rimming steel, stabilized steel, 70/30 brass and aluminium were used to give a wide range of general properties. All the materials were tested in the annealed condition. Two thicknesses of brass and aluminium, 0.036 in. (0.91 mm.), and 0.048 in. (1.22 mm.), and one thickness of each of the two steels, 0.036 in., were drawn. The first series of tests on aluminium did not correlate well, for reasons which will be described, so a second series was run using only 0.036-in. thick material. The general properties of each metal are given in Table I. Each thickness of metal tested was taken from one coil and the compositions were :—

70/30 brass	..	To British Standard 267.
Aluminium	..	Cu >0.03, Mn >0.05, Si >0.50, Fe >0.60, Zn >0.03, remainder Al (per cent).

*Research Department, Imperial Chemical Industries Ltd., Metals Division, Birmingham.

† Defined as the $\frac{\text{Maximum Blank Diameter}}{\text{Punch Diameter}}$. The Maximum Blank Diameter was taken as "that diameter of blank for which there is an equal chance of success or failure." In calculating this value it was assumed that the number of failures varied linearly with size.

TABLE I—*Properties of Metals Tested*

Material	Thickness		Hardness, Vickers diamond pyramid	0.1 per cent proof stress† (tons per sq. in.)	Ultimate tensile strength† (tons per sq. in.)	Elongation on 2 in. gauge length† (per cent)	Surface roughness† centre-line average, micro-inches		Grain-size, mm.
	in.	mm.					One side	Other side	
Brass	0.038	0.965	72	7.66	21.85	56	8	7	0.06
Brass	0.048	1.22	67	6.63	21.20	55	9	8	0.04
Aluminium (first series)	0.035	0.89	20	2.82	5.59	36	4	10	0.06
Aluminium (first series)	0.047	1.19	22	2.86	5.52	33	4	10	0.06
Aluminium (second series)	0.036	0.91	20	2.19	5.56	41	15	15	0.02/0.03
Rimming steel, non-skin passed	0.036	0.91	42.5*	16.4Y	20.4	50	39	48	—
Stabilised steel non-skin passed	0.036	0.91	41.5*	15.7Y	20.2	50	86	82	—

* Rockwell B scale.
† Mean of readings taken in, and at 90 deg. to, the direction of rolling.
Y Lower Yield point.

Rimming steel .. C 0.047, S 0.029, P 0.012, Mn 0.33, Ni 0.047, Cu 0.044, Sn <0.01 (per cent).

Stabilized steel .. C 0.054, S 0.024, P 0.014, Mn 0.29, Ni 0.074, Cu 0.062, Al 0.032 (per cent).

Presses and Tools

The three presses used, each with its own set of tools, were owned by members of the British Deep Drawing Research Group and are designated A, B and C. All presses had an hydraulically operated main ram moving vertically and carrying the test punch. The blankholder, which clamped the blank to the die face, was gas operated for presses A and B and hydraulically operated from a dead weight accumulator for press C. A constant punch speed of 8 to 9 ft. per min. (4.1 to 4.6 cm. per sec.) was used for all tests.

Each punch was $50^{+0}_{-0.05}$ mm. diameter, flat headed and with an edge radius of 5 ± 0.1 mm., blending with the sides and base smoothly. Each press used one die covering both blank thicknesses tested, of inside diameter $53.64^{+0}_{-0.05}$ mm., and edge radius 13.0 mm., the latter again being blended smoothly with adjacent surfaces. Punch, die and blankholder of all presses were made of good quality tool steel of minimum hardness 700 V.P.H.

Surface roughness figures for the three sets of tools were measured at various points (Fig. 1) by the "Talysurf" Model 2 surface measuring instrument and are given in Table II—a typical trace of die A is shown in Fig. 2*a*. All tools initially had a surface roughness of less than 20 microinches (0.5 microns), centre-line average, on all parts which came into contact with the blank when drawing. Rechecks of the finish were made before each series of tests on each metal and no change was noticeable.

Fig. 1.—*Positions of surface roughness readings*

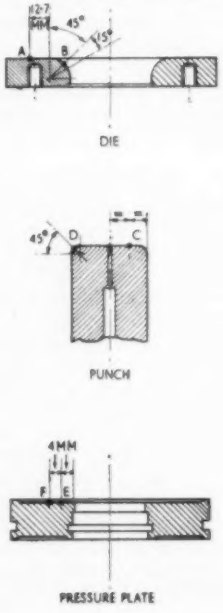


TABLE II—*Surface Roughness of Press Tools*

Tool	Position at which reading was taken (*see* Fig. 1)*					
	A	B	C	D	E	F
Punch .. .. .. A	—	—	7	5	—	—
Die .. .. .. A	15	3	—	—	—	—
Pressure plate .. .. A	—	—	—	—	10	9
Punch .. .. .. B	—	—	7	4	—	—
Die .. .. .. B	3	11	—	—	—	—
Pressure plate .. .. B	—	—	—	—	5	5
Punch C	—	—	3	4	—	—
Die C	3	3	—	—	—	—
Pressure plate C	—	—	—	—	11	10
Die repolished .. .. B	3	4	—	—	—	—

* All readings given in micro-inches, centre-line average, and obtained by radial traverse of stylus.

Preparation of Blanks and Lubrication Procedure

The initial surface roughnesses of the sheets from which blanks were cut are given in Table I. Readings were taken in the direction of rolling and transverse to it. The sheets were then guillotined to 5-in. (127-mm.) squares and covered each side with a protective layer of paper. Following this, the aluminium and brass blanks were rough cut on a bandsaw and turned to size using the adaptor shown in Fig. 3, while the steel blanks were trepanned singly direct to size. The tolerance on the blank diameters was fixed at −0.001 in. (0.025 mm.) to −0.003 in. (0.076 mm.) so that the blanks could be fitted easily into the locating rings* on the presses. After machining the blanks were deburred and then degreased by swabbing with carbon tetrachloride. Immediately before drawing they were coated with a thin film of lubricant (having properties and make-up as defined by Kemmis[1]) by dipping and passing between pre-set plastic-coated rollers. A thin smear of the same lubricant was applied to the punch, die and pressure plate before testing commenced.

* The locating rings were used to centralize the blank to within 1 per cent of the punch diameter(1).

Blankholding Loads

It was first necessary to determine for each metal the blankholding load necessary to prevent flange wrinkling. For this 4-in. (101.6-mm.) diameter blanks were drawn approximately 1 in. (25.4 mm.) high on press A and examined. The blankholder pressure was increased for one blank after another until wrinkling was just suppressed, and the appropriate pressure noted. Pressures then used for all the correlation tests were 50 to 70 per cent(1) above these values, *viz.*, for brass 15 lb. per sq. in. (1.06 kg. per sq. cm.), for aluminium 10 lb. per sq. in. (0.70 kg. per sq. cm.), for steels 50 lb. per sq. in. (3.52 kg. per sq. cm.).

Since press B had the same blankholding arrangements as press A, no difficulties were evident in this application, but preliminary tests on press C (hydraulic blankholding) showed that the friction in the movement of the dead weight accumulator system was too high for sufficient accuracy at the low pressures associated with aluminium. Further, the blankholder C was larger than the other two, so that to maintain a constant blankholding load comparable with A and B it was necessary, for example, to drop the blankholder pressure C to 12 lb. per

Fig. 2a.—Die Radius. Radial Trace. 2.2 *micro-inches, c.l.a.* (×10,000/200)

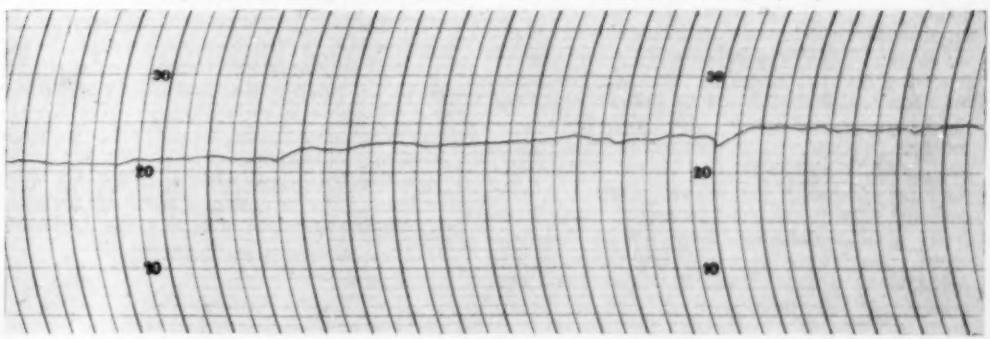


TABLE III—*Swift Cupping Test Results on Different Presses*

(*a*) *For Brass*

Tools and press	Thickness, in.	Blank size, in. 4.350		4.400		4.450		Maximum blank size		Limiting drawing ratio	Maximum variation in L.D.R.
		D†	F*	D	F	D	F	in.	mm.		
A	0.038	6	0	6	0	0	6	4.425	112.3	2.246	0.023
B	0.038	6	0	1	5	—	—	4.380	111.4	2.223	
C	0.038	6	0	1	5	0	6	4.380	111.4	2.223	
A	0.048	6	0	2	4	0	6	4.387	111.5	2.227	0.009
B	0.048	5	1	0	6	—	—	4.370	111.1	2.218	
C	0.048	6	0	0	6	—	—	4.375	111.2	2.221	

† Drew successfully. * Failed.

(*b*) *For Aluminium (First Series)*

Tools and press	Thickness, in.	Maximum blank size, mm.	Limiting drawing ratio	Maximum variation in L.D.R.
A	0.035	113.0	2.259	0.083
B	0.035	109.0	2.176	
A	0.047	110.5	2.208	0.062
B	0.047	107.3	2.146	

(*c*) *For Steels—Thickness* 0.036 *in.*

Tools and Press	Blank size, in. 4.35		4.40		4.45		4.50		4.55		4.60		Maximum blank size, mm.	Limiting drawing ratio	Maximum variation in L.D.R.
	D	F	D	F	D	F	D	F	D	F	D	F			
Rimming steel															
A	6	0	6	0	1	5	—	—	—	—	—	—	112.6	2.252	0.028
B	5	1	1	5	0	6	—	—	—	—	—	—	111.2	2.224	
Stabilized steel															
A	—	—	—	—	—	—	6	0	0	6	—	—	115.0	2.300	0.016
B	—	—	—	—	—	—	6	0	4	2	0	6	115.8	2.316	

sq. in. for brass. For these reasons, it was decided to correlate between the two presses A and B only but also to check with C for brass under these slightly different conditions.

Procedure and Results

The punch, die and blankholder were cleaned with trichlorethylene and carefully centralized before testing. It was known from previous work in which range the maximum blank size was likely to occur. Single blanks covering this range in increasing diameter steps of 0.050 in. (1.27 mm), were tested to find more exactly the position of the maximum blank diameter. Six blanks (as recommended by Svahn[2]) at each increment, covering just above to just below, the critical region were then manufactured and tested, giving a reliable coverage from which the Limiting Drawing Ratio could be determined according to which definition of this quantity was assumed. This procedure was followed on presses A and B for brass and aluminium of both thicknesses and the results are given in Table III. For brass, correlation was very good ; the maximum discrepancy of results was on increment of blank size which cannot be improved upon since, other factors apart, the blank diameter tolerances themselves preclude repeatability to within less than one increment. On testing the brass on press C these results were further confirmed. For aluminium, however, the observations showed a variation of two or more increments of maximum blank diameter between the two sets of apparatus. Further tests were then made with this metal keeping closer control of material and tool surface quality. The first batch (*see* Table I) had a difference in surface quality from one side to the other. For the batch now used (of 0.036 in. thickness), the roughness on each side was the same. In addition, to decide whether differences might have been due to the tools of A and B or the presses, the following sequence of testing was adopted :—

(1) Test on press A with tools A ;
(2) Repeat ;
(3) Test on press B with tools A ;
(4) Test on press B with tools B.

TABLE IV—*Swift Cupping Test Results on Different Presses*
Aluminium—Second Series—Thickness 0.036 in.

Test No.	Press	Punch	Die	Blank size (in.) 4.25 D	4.25 F	4.30 D	4.30 F	4.35 D	4.35 F	4 40 D	4 40 F	4.45 D	4.45 F	Limiting drawing ratio	Maximum variation in L.D.R.
1	A	A	A	—	—	6	0	4	2	1	5	—	—	2.217	0.051
2	A	A	A	—	—	6	0	6	0	0	6	—	—	2.221	
3	B	A	A	—	—	6	0	6	0	1	5	—	—	2.223	
4	B	B	B	0	3	—	—	—	—	—	—	—	—	—	
5	A	B	A	—	—	—	—	6	0	6	0	0	6	2.246	
6	A	B	B†	6	0	4	2	2	4	0	6	—	—	2.195	
7	B	B	B	6	0	6	0	0	6	—	—	—	—	2.195	

† Die re-polished.

Results are given in Table IV. The first three tests were satisfactorily in agreement. For Test 4, however, the tools B caused failure of the cups at a much lower blank size than in the tests preceding. Some difference in the two sets of tools was thus indicated and this could only have been caused by a difference in surface quality as checks showed that dimensionally the two sets were identical. Test 5, therefore, was made with die A and punch B, and gave a slightly better performance in drawing than Tests 1, 2 and 3. This proved that punch B was satisfactory and indicated that die B was the cause of the premature failure. Upon examination of die B under a microscope surface imperfections or trail marks of the type illustrated in Fig. 4 were discovered. (These are discussed further in a later section of the paper). The die was repolished, using 600-grit emery paper and then $\frac{1}{4}$-micron cloth, but the deepest marks, while not noticeably affecting " Talysurf " centre-line average readings, could not be eliminated without danger of altering the die contour. Test 6 was then carried out on press A with tools B and showed a drop of approximately one increment in maximum blank size compared with Test 1 (*see* Table IV). As there was good reason for this in the inferior surface quality of die B, these results were accepted as giving satisfactory correlation. Finally, for the aluminium, Test 7, made with press and tools B as in Test 4, agreed very well with Test 6 and was considered satisfactory.

Tests on both steels were then performed on presses A and B and results correlated ideally for stabilized steel and just outside of one increment for the rimming steel (Table III*c*).

II—Roughness Trials

The correlation trials, particularly for aluminium, highlighted the importance of tool surface preparation but did not show the individual significance of punch, die and material surface roughness on drawing results. In addition, it was evident that a surface finish reading in itself was insufficient definition and that it must also be coupled with a uniformity of surface preparation to obtain reliable results. The effect of tool surface roughness was, therefore, examined on one press for a range of finishes of stabilized steel, brass and aluminium of the same nominal compositions as before. For these trials the testing conditions were similar to those for the correlation tests but with the special preparation to tools and material set out hereafter. While the aluminium was from the same coil as the second series (Table I), the brass (thickness 0.045 in.) and steel (0.036 in.) had slightly different properties from those used previously, though

Fig. 2b.—Die Radius. Circumferential Trace. 19 *micro-inches, c.l.a.* (×10,000/200)

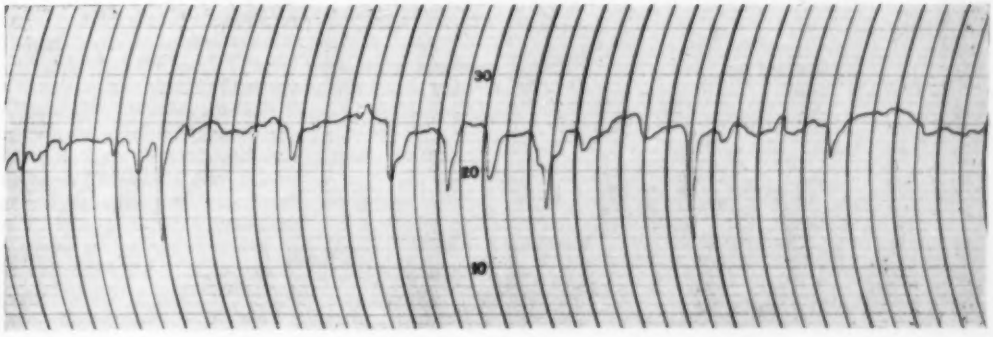


TABLE V—*Variation of Metal and Tool Surface Roughness—Swift Cupping Results*

Test No.	Material	Surface roughness			Blank diameter, in.																Maximum blank diameter (in.)	Limiting drawing ratio
					4.20		4.25		4.30		4.35		4.40		4.45		4.50		4.55		4.60		4.65			
		Material	Punch	Die	D	F	D	F	D	F	D	F	D	F	D	F	D	F	D	F	D	F	D	F		
1	Aluminium	S	S	S									6	0	0	6									4.425	2.247
2	”	R	S	S							6	0	4	2	0	6									4.412	2.241
3	Brass	S	S	S							5	1	2	4	0	6									4.384	2.226
4	”	R	S	S							6	0	1	5	—	—									4.380	2.224
5	Steel	S	S	S							—	—	—	—	6	0	6	0	0	6					4.525	2.298
6	”	R	S	S							—	—	—	—	—	—	6	0	6	0	6	0	0	6	4.625	2.348
7	Aluminium	S	R	S							—	—	—	—	6	0	0	6							4.475	2.273
8	”	R	R	S							—	—	0	6	—	—	—	—							4.367	2.218
9	Brass	S	R	S							9	3	6	0	0	6									4.425	2.247
10	”	R	R	S					6	0	8	4	5	7	0	6									4.384	2.226
11	Steel	S	R	S					—	—	—	—	—	—	6	0	1	5	0	6	—	—			4.480	2.275
12	”	R	R	S					—	—	—	—	—	—	—	—	6	0	3	3	0	6			4.550	2.311
13	Aluminium	S	R	R	6	0	2	4	0	6	—	—	—	—	—	—	—	—	—	—	—	—	—	—	4.238	2.151
14	”	R	R	R	6	0	5	1	1	5	—	—	—	—	—	—	—	—	—	—	—	—	—	—	4.275	2.167
15	Brass	S	R	R	—	—	—	—	6	0	3	3	0	6	—	—	—	—	—	—	—	—	—	—	4.350	2.208
16	”	R	R	R	—	—	—	—	6	0	4	2	0	6	6	0	—	—	—	—	—	—	—	—	4.362	2.214
17	Steel	S	R	R	—	—	—	—	—	—	—	—	—	—	—	—	4	2	0	6	—	—	—	—	4.512	2.290
18	”	R	R	R	—	—	—	—	—	—	—	—	—	—	6	0	6	0	5	1	0	6	—	—	4.570	2.320
19	Aluminium	S	S	R	—	—	—	—	6	0	1	5	—	—	—	—	—	—	—	—	—	—	—	—	4.330	2.198
20	”	R	S	R	—	—	—	—	6	0	0	6	—	—	—	—	—	—	—	—	—	—	—	—	4.325	2.195
21	Brass	S	S	R	—	—	—	—	4	2	0	6	—	—	—	—	—	—	—	—	—	—	—	—	4.312	2.189
22	”	R	S	R	—	—	—	—	5	1	0	6	—	—	—	—	—	—	—	—	—	—	—	—	4.320	2.193
23	Steel	S	S	R	—	—	—	—	—	—	—	—	—	—	6	0	4	2	0	6	—	—	—	—	4.512	2.290
24	”	R	S	R	—	—	—	—	—	—	—	—	—	—	—	—	6	0	4	2	1	5	—	—	4.567	2.318

again, for any one material all the blanks came from one coil.

Properties were:

Brass—0.1 per cent proof stress 6.82 tons per sq. in., elongation on 2 in.—70 per cent, otherwise as in Table I for thick brass.

Stabilized steel, skin passed—Hardness 44 Rockwell B, yield point 11.6 tons per sq. in. (taken at the limit of proportionality)—otherwise as in Table I.

Tool Surfaces

The range of tool surface roughness of 0 to 20 microinches(1) has not previously been examined and thus both limits, apart from the fact that they have been utilized before, are somewhat arbitrary. It was decided, therefore, to test at the extremities of this range for the punch and die but to hold the pressure plate roughness constant at 10 microinches. There were, thus, four combinations for testing:— (*a*) Smooth punch and die; (*b*) smooth punch with rough die; (*c*) rough punch and die; (*d*) rough punch with smooth die.

Smooth tools, denoted S in Table V, were made with a roughness of 0 to 5 microinches, centre-line average and rough, denoted R, were within the range 18 to 20. To obtain the smooth surfaces on punch and die, they were abraded in a lathe with 600-grit silicon-carbide paper and then with 0.25-micron diamond paste. Stylus travel for the "Talysurf" measurements was radial and measurements were taken at points A, B, C and D (Fig. 1), at 60-deg. intervals around the tools.

For the rough surfaces, the die was abraded radially to simulate drawing wear and the punch was roughened circumferentially to simulate poor polishing, this being more likely in practice than severe wearing. Abrasion of both tools was by grade 60 silicon-carbide paper backed by a felt pad and soaked

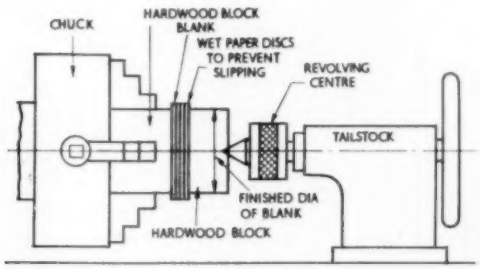
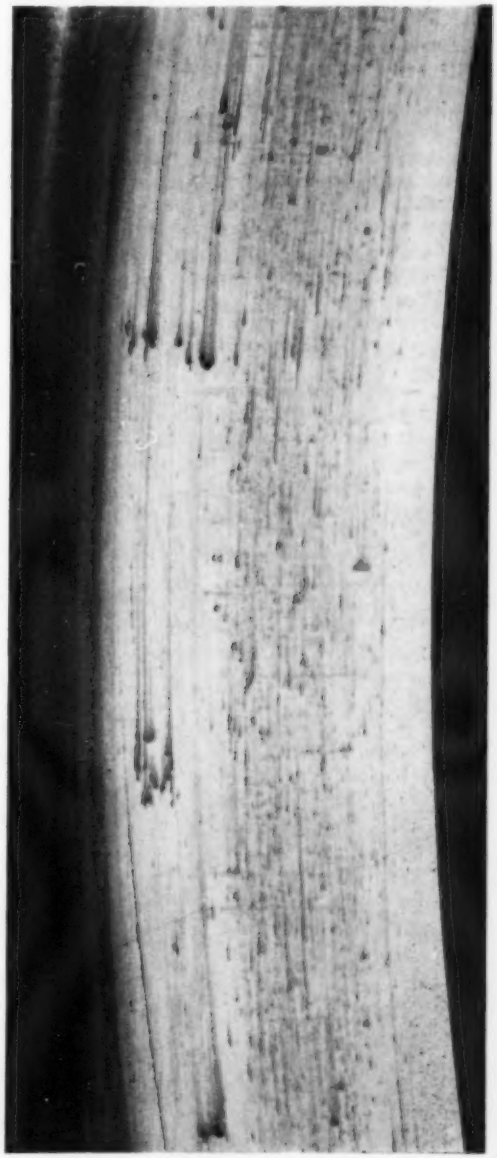


Fig. 3 (left).—Lathe adaptor for turning blanks

Fig. 4 (below) (approx × 7).—Trail marked surface of die "B"



in paraffin to keep the paper free-cutting. Surface finish measurements were taken at 60-deg. intervals around the die by circumferential stylus travel at points A and B* (Figs. 1 and 2*b*) and at the same intervals, using radial travel, around the punch (points C and D).

At the blending in of curved and flat surfaces for the tools the radii, checked by replica and shadowgraph techniques, did not vary by more than 0.07 mm. total from the standard value(1).

Metal Blank Surfaces

The surface quality of rolled strip varies, not only in roughness, but in other ways, such as adherent scale, lubricant, drying or pickling residues, rolling marks, etc. For the basic purpose of this work, therefore, surface roughnesses on the blanks were produced artificially by multi-directional abrasion. Two surface roughnesses in each material were first measured representing about the highest and lowest values normally supplied commercially for drawing purposes.

These were :—

		Microinches C.L.A.
Aluminium and brass ..	Smooth	0 to 5
	Rough	15 to 20
Steel	Smooth	35 to 45
	Rough	60 to 70

(Smooth and Rough are denoted by S and R in Table V.)

The surfaces were then prepared to these finishes in various ways using different grit papers and emery cloths, in oil and paraffin, with and without felt backings. All rolling marks were removed and all surfaces were, as far as was possible, made non-directional. "Talysurf" readings were taken on both sides of each blank at four positions, 90 deg. apart and approximately 1 in. in from the edge. Stylus travel was radial.

* To traverse the stylus of the "Talysurf" in a circumferential direction on the die radius was not possible using normally supplied accessories, so a modification was made to the instrument. This took the form of a small block (*see* Fig. 5) which turned the pick-up through 90 deg. This, in conjunction with the radius attachment, allowed measurements to be taken in bores down to about 0.05 in. The only criticism of this arrangement is that the stylus traversed sideways (*i.e.*, 90 deg. to normal) but on checking with an etched glass standard there was no indication of error.

Procedure and Results

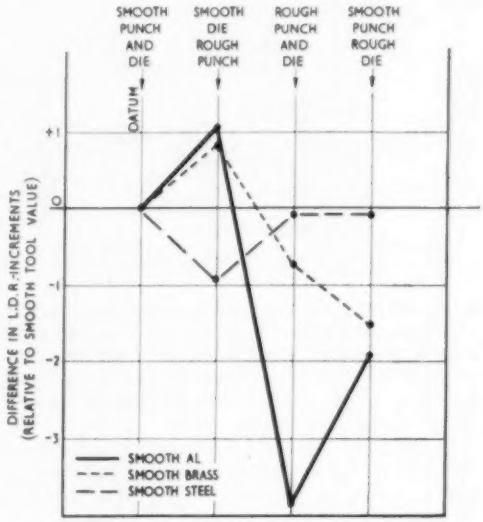
All the blanks were swabbed with trichlorethylene before testing, allowed to dry and lubricated. The same punch and die (from press A) was used throughout the tests, the only modifications being to the surface roughness. The sequence of testing was to draw in ascending order of metal roughness to avoid, as far as possible, effects of pick-up. In fact, pick-up only occurred once, and that during the last steel tests. After each combination of tools had been tested, surface measurements on them were repeated to check for any variation in roughness due to drawing. No variation occurred at any stage.

The full listed results are given in Table V and Figs. 6 and 7 give the plots of differences in L.D.R. due to tool surface quality for smooth and rough material. Fig. 8 illustrates the effect of material surface quality for different tool combinations.

It should be emphasized in interpreting the results that the smooth and rough values of the steel blanks are much higher than for the brass and aluminium. Bearing this in mind, the most important features which the experiments demonstrated were :—

(*a*) Considering the overall tool and surface roughness combinations, the only metal which gave differences in Limiting Drawing Ratio outside of two increments was the aluminium, for which differences rose to five ;

(*b*) Blank surface roughnesses for brass and aluminium made little difference to L.D.R., though



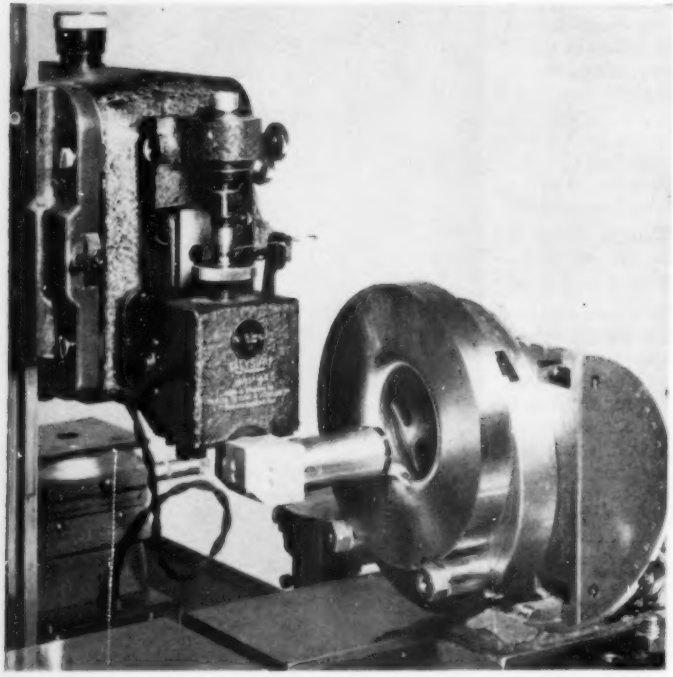


Fig. 5 (left).—Arrangement for tool surface measurement showing modification to pick-up assembly

Fig. 6 (above).—Change in Limiting Drawing Ratio with tool surface roughness—smooth material

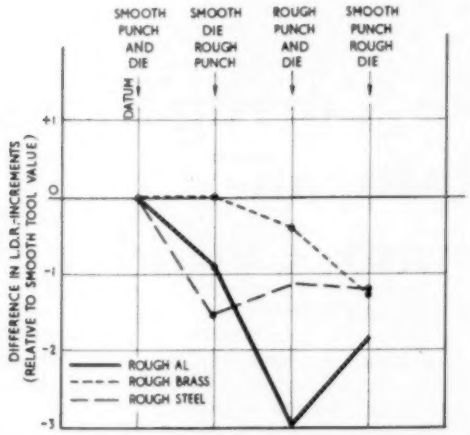


Fig. 7.—Change in Limiting Drawing Ratio with tool surface roughness—rough material

with a rough punch and smooth die with aluminium the drawing performance of the smooth material was two increments better ;

(*c*) With all combinations of tooling, the rough steel drew better than the smooth ;

(*d*) Surface quality of tools will have to be controlled to closer than 20 microinches, centre-line average, if the maximum deviation in Swift cupping results is to be kept within one increment.

Discussion

Though the investigation can be considered to be limited in both material and surface roughness range examination, the combination of the correlation and roughness tests required hundreds of cupping tests and thousands of surface finish readings. Sufficient evidence is available from which to draw reliable conclusions. For aluminium, in particular, it has been clearly revealed, both from the correlation tests and the surface roughness tests, that the increment in Limiting Drawing Ratio should be doubled from 0.025 to 0.050 to give comparable results with brass and steel. Similarly, if correlation between presses is to be expected within one increment, tool roughness range should be reduced to 0 to 10 microinches, centre-line average. The range of 0 to 20 microinches allows no closer definite agreement than two increments of L.D.R. The more limited range would seem to favour the use of tungsten carbide tools, where wear of surfaces is very much less.

It seems clear that the careful testing needed to produce reliable results using the test in its present form is impossible in use as a shop floor test and is nearly impossible and certainly very expensive to investigate as a standard. Currently, universities and research and industrial organizations, in order to participate in the investigation of the test, must be equipped with, or have access to, surface roughness measuring instruments together with attachments for measuring on radiused surfaces. Attention has not been paid to these features in the past but they would appear to be necessary in the future. Nevertheless, it is only by extremely careful and possibly tedious investigation that a simple and reliable shop floor test, which is certainly needed, can be developed and the governing variables of the cupping operation specified.

In conclusion, a brief comment is necessary on the type of fault or trail mark discovered in the correlation tests on aluminium. This fault was not exposed by centre-line average figures on the "Talysurf" and can only be overcome by ensuring that the tool grinding and hand dressing operations do not leave such faults in their wake, or by specifying a "peak-valley height" for the working surfaces.

Acknowledgments

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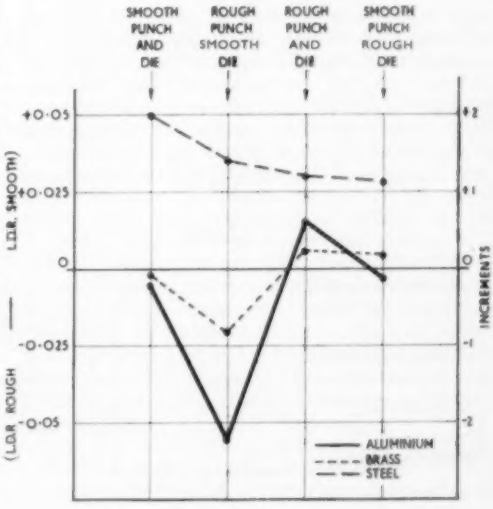
2. Svahn, O. *Journal Iron and Steel Institute*, 1954, **177** (Part I), p. 129.

Fig. 8.—Change in Limiting Drawing Ratio between rough and smooth material



PRESSING

Decorative Corrugations into an Aluminium Cylinder

By "TARENTFORD"

CORRUGATIONS, of the type illustrated in Fig. 1 can have a dual role. As a decorative feature, they relieve the plain surface and improve the general appearance of an article, or they can provide a very efficient gripping surface when it becomes necessary to apply torque to the part. In this case the cylinders came in the former category, and to add to their appearance, the length of the grooves was different—alternate members being long and short, appearing for a little more than a third of the distance along the cylindrical wall.

The cylinders were initially produced by impact extrusion, and the final thickness of the material prior to forming the corrugations was about 0.01 in. The shells were not trimmed until after pressing the grooves as any tendency toward distortion would mean the trimming operation was again required, thus repeating an operation which is easily handled at a single workstage.

The press-tool for forming these grooves is of comparatively simple design and the chief characteristics are shown in Fig. 2. For this process hardened balls are used as forming members, and are so arranged around the periphery of the shell that when the top tool pushes the shell downward, the balls "iron" the corrugations into the material. For illustration purposes the drawing is exaggerated as the actual depth of groove required is not so great as shown. The balls appear to stretch the metal rather than distort it, because the outside diameter is held closely and prevents any but an upward movement of the pieces.

The long cylinder is initially placed in the component locator "A," and the descending ram causes the top punch "B" to push the shell farther down into the die until it makes contact with the protruding balls let into the side walls of "A." These balls are held in place by heavy-gauge springs and holder "D"—which is specially coned to form a seating and ensures a firm grip on each ball, at the same time providing a square shoulder against which the spring can exert the necessary pressure. The balls forming the long grooves operate first, and as the shell is pushed down into the tool, the remaining corrugations are pressed.

The process is completed when the shell bottoms against the pad "H," and a pneumatic cushion lifts the article from the die or locator "A." The upward movement causes the balls to move outwards and upwards but the springs retain them in place against the walls of the shell. The amount of movement given to these balls is thus small. The downward pressure causes them to move inward and lock against the countersink made in "A," and also retains and prevents them falling into the die aperture. Some care is therefore necessary in the production of the ball cavity, they must assemble easily during the initial construction of the tool, and remain in place with a movement of only a few

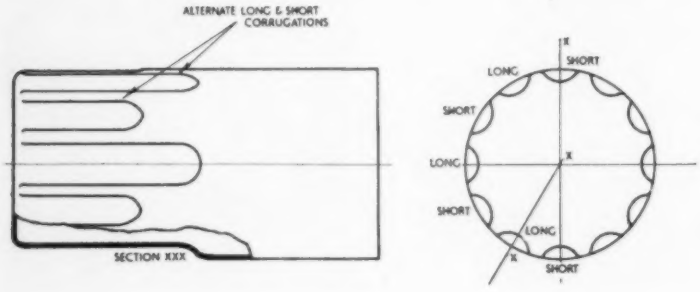


Fig. 1.—Corrugations on a shell of this type are useful as a decorative or utilitarian feature, but their introduction creates an unusual tooling problem in both design and manufacture

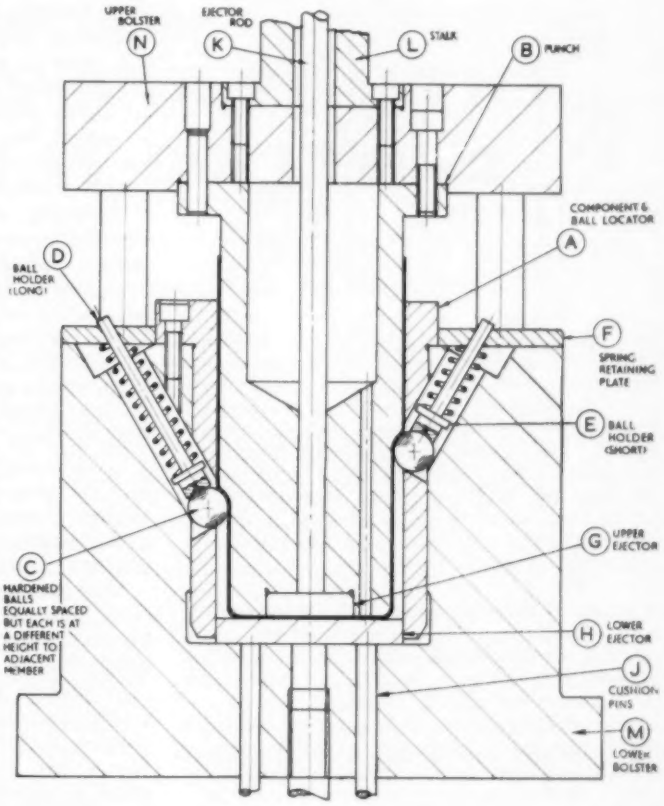


Fig. 2.—A massive bolster is the feature of this tool together with the method of controlling the balls that form the grooves. Spacing the latter at intervals provides the necessary projections to form the grooves

thousandths of an inch during the release of the component.

Fig. 3 is a composite drawing showing how this is accomplished. The first stage is the boring of deep countersinks at the required distances round the periphery of the detail. These are so arranged to prevent the balls from entering the die too far, and in fact control the depth of the groove imparted to the component. A typical hole is shown on the left-hand side of the drawing.

Next, a slot is necessary to allow a ball to drop into place when the long sleeve is located in the bolster and to provide a clearance for the ball holders " D "; this is accomplished by sinking a cutter on a vertical milling machine as shown on the right-hand side of this detail at Fig. 3. Only enough material is machined away to allow a ball to drop in place, and the circular portion of the countersink is retained to hold the ball. The flange is milled away to give the required clearance for the spring-retaining plate " F " and three screws securely hold it against the upward pressure as the ram rises. As this detail was of considerable length and matching each slot with the holes bored in the bolster to clear the balls was essential, a method was needed facilitating easy assembly with all the holes correctly aligned.

Detail "A" was thus finished ground on the outside diameter which locates in the bolster and then placed in an ordinary domestic refrigerator and allowed to remain there overnight. There was a difference of only 0.0005 in. between the two diameters—the die being, of course, that much larger, but on quickly taking it at a temperature below freezing it was easily dropped into the bolster and secured by the screws when it was assured the parts matched correctly. A final skim through the bore on an internal grinding machine removed any distortion that may have occurred.

There is the possibility of a shell adhering to the upper tool, and an upper ejector " G " attached to the rod " K " is used to free any shell that may stick to the punch. The ejector is located in a recess in the top bolster and a hole is drilled alongside the ejector to permit any air trapped in the shell to escape.

Long shells require a high bolster for the lower tool especially when it is necessary to carry the component a long way into the die. The drawing is an example of this condition, and the thick walls of this bolster are needed in case heavy strains cause it to burst. Aluminium details of this thickness are not in this category and even an iron bolster, instead of a steel member which is occasionally used, is unnecessary. Finally, a highly-polished surface is essential as a means of promoting an excellent finish to the component. The balls take care of the grooves but the removal of all sharp edges round the ball cavity is undertaken by a tiny pencil grinder and polished as a precautionary measure.

About $\frac{1}{4}$ in. is left on the end for trimming. Drawing the shell and following this with the array of grooves, does cause considerable waviness about

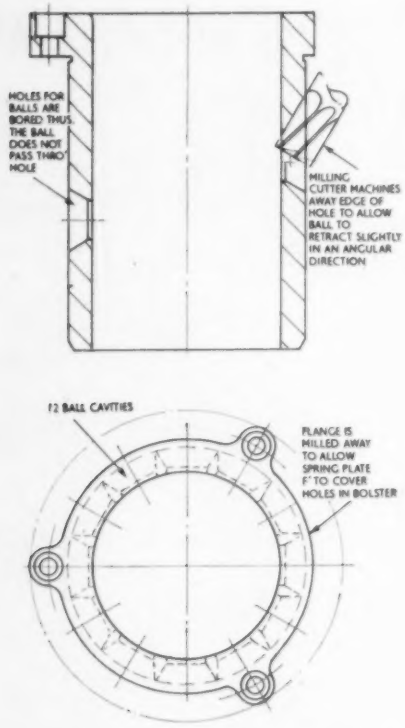

HOLES FOR BALLS ARE BORED THUS. THE BALL DOES NOT PASS THRO' HOLE
MILLING CUTTER MACHINES AWAY EDGE OF HOLE TO ALLOW BALL TO RETRACT SLIGHTLY IN AN ANGULAR DIRECTION
12 BALL CAVITIES
FLANGE IS MILLED AWAY TO ALLOW SPRING PLATE 'F' TO COVER HOLES IN BOLSTER

Fig. 3.—A sketch of the ball holder or die showing how the countersinks for retaining the balls are produced

the top edge, and this is corrected with the set-up illustrated in Fig. 4. Here the shell is located on a mandrel by the locators " C " and controlled for position by the stop " E." Movement of the expander "A" causes the locators to move outward and hold the shell on what is a truly circular portion of the diameter. Circlips prevent the locators from falling apart and a trimming tool, mounted at the rear, removes the unwanted material and restores a correct edge. In order to maintain a perfectly flat face in relation to the locators, the stop " E " is recessed into the expander and finally held in position by means of the threaded portion.

Some consideration was given to the possibility of producing these grooves during the impact extrusion process and had conditions made this possible undoubtedly it would have been more economical to manufacture these cylinders in this manner, but varying numbers of grooves on shells having the same diameters meant that a single extrusion tool of simple characteristics was able to produce them quickly and the press tool introduced the corrugations; often only comparatively small quantities were needed of one particular type and it was thus possible for production to proceed on a long run while a few shells were put through an alternative press tool. No attempt was made to oil the components for this corrugating process and there was virtually no marking of the side walls.

This process is applicable to other forms of production, one of them being the pressing of a keyway in a cylindrical article, and the introduction of a ball in this manner is a much more effective and cheap way of making the die than endeavouring to machine it from solid metal. Control of the ball is an essential feature of the design, and heavy-gauge springs are necessary rather than those made from thin wire as the balls must not retract when the component starts to lift. Finally, though the balls are held tightly, they are still not completely restrained from rotating as the punch descends, and allow the balls to move and continually present a fresh surface to the shell wall; thus flats are never worn on them and the finish produced is always of a high quality.

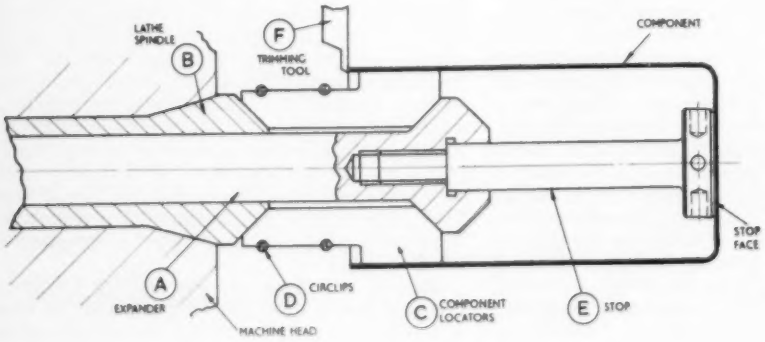


Fig. 4.—Trimming is the final operation and this is accomplished with the aid of the mandrel illustrated here. Simplicity is the keynote of this design and an accurately machined edge results

An Introduction to the

THEORY AND PRACTICE OF FLAT ROLLING—2

By the late C. W. STARLING, B. Eng., A.M.I.Mech.E.

(*Continued from page* 690, *September*, 1960 *issue*)

THE ROLLING PROCESS

FROM the earliest days of the Christian era, metals such as lead, gold and silver, were known and crude methods of casting irregular shaped objects were in use. The metal workers of those days had already found that cast objects tended to be brittle and had learned the technique of casting bars and forging the metal into the required shape by beating with stone hammers. Objects made from these easily formable metals had insufficient strength for any real practical use and they were used mainly for decorative purposes.

Even with soft metals, hand hammering was a laborious process and over 2,000 years ago in the Far East, heavy stone hammers had been made and mounted in groups with a water wheel driving them. With the advent of a technique for smelting iron from iron ore, it became apparent that for any real use to be made of this new " wonder metal," more effective machinery would be required.

As with many major inventions, it is impossible to say who was responsible for the first rolling mill. It is known that simple wooden rollers, mounted in pairs on a bamboo framework, and turned by hand, were used for extracting sugar cane in the early part of the fifteenth century. It was a small step from this to a heavier pair of metal rolls to roll the soft precious metals, followed by attempts to roll red-hot steel in small bars. Although no one man can be said to have invented the rolling mill, is it known that the great scholar Leonardo da Vinci in one of his many notebooks, had sketched his ideas for a simple metal-rolling mill. An amazing feature about this was that even before mills had been used, he had realized the necessity for back-up rolls and one of his sketches showed a pair of long, small-diameter rolls with narrow, larger-diameter rolls, supporting the middle of the working rolls. About this time, in the middle of the 15th Century, simple mills were being made on a very small scale to make gold lace and for other decorative work in soft metals.

Little progress was made in rolling until the beginning of the 17th Century and there is evidence to show that simple 2-high mills with cast-iron rolls mounted in wooden framework, were being used for rolling lead and tin into sheets. Some attempt was being made to gear the two rolls together and to adjust the gap by wedges. About this time too, the possibility of using grooved rolls was realized and simple bars were being rolled in lead. By the end of the century, larger iron rolls were being cast and heavier mills were being built with horses to drive them and eventually with water-wheel drives. It was now becoming possible for a more powerful mill to roll hot-iron plates as well as the softer metals.

From these first crude attempts to roll iron there was a slow but steady development in rolling mills and by the middle of the 18th Century the mill was beginning to look like a crude version of the modern one. The development of mills was restricted by the power available and it was soon found that small-diameter rolls required less load on them and, therefore, a lighter housing support and less power. The idea of using large supporting rolls for small-diameter working rolls was then put into practice to give a "4-high" mill almost 300 years after Leonardo da Vinci had first suggested it. For the next 100 years there was little change in basic mill design, but the size of rolls and mill housings increased enormously, and the whole art of rolling was changing from a simple, leisurely process to a high production process and the advent of the steam engine around the end of the 18th Century helped enormously in increasing mill outputs.

Now that the practice of rolling was well established, inventors were quick to see the possibility of different roll combinations and in the second half of the 19th Century there was a constant flow of patents dealing with rolling mills. A number of the roll arrangements patented around this period are shown in Fig. 17. Most of these had a short life, if used at all, and the simple 2-high, 3-high or 4-high design maintained their position virtually unchallenged until relatively recent times, when most of these old roll combinations have been revived for special mills.

It will be seen, therefore, that almost 200 years ago rolling mills had virtually taken up their present

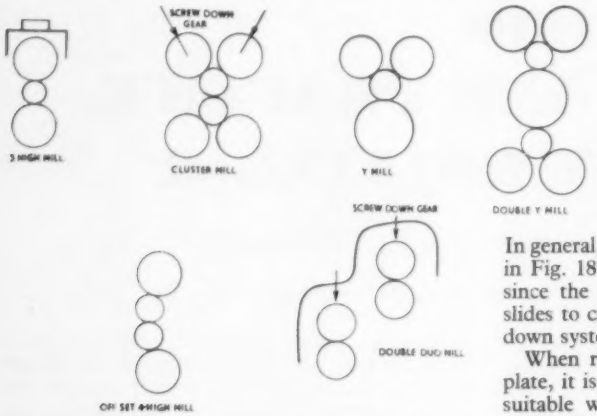


Fig. 17.—Some of the roll arrangements patented in the second half of the 19th century

form and most of the ancilliary equipment had been in use in a crude form. Development consisted of vast increases in power and size, with steam engines reaching as much as 15,000 to 18,000 h.p. It is interesting to note at this point that many steam engines of considerable age are still giving excellent service in driving slow-speed heavy-duty mills and it is only in recent years that the last of the water-wheel drives have been finally removed.

While the rolling mill has been developing as a machine for the working of metals, its place in the whole structure of steel manufacture has become firmly established. A large proportion of the steel in use in the world has passed through a rolling mill at some stage in its production and only a small percentage is cast or forged directly from the ingot.

The general procedure for manufacturing rolled steel has, to a large extent, become standardized, high-purity iron being obtained from the blast-furnace, then converted into steel and cast into ingots ready for rolling. For high-production steel making the open-hearth furnace reigns almost supreme and furnaces up to 250 tons capacity are in use. These furnaces produce a large quantity of steel at intervals of five or six hours, but they are now competing with the Bessemer converters, which produce small quantities at much more frequent intervals. In small production of high-alloy steels or steels with a very accurate analysis, the arc furnace is coming into prominence and it is probable that all high-alloy steel will, in future, be made in electric-arc furnaces.

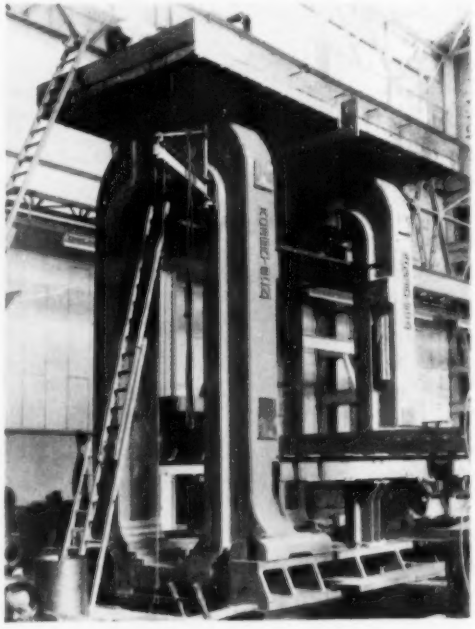
Whatever type of furnace is used to produce the steel, it is almost universal to cast from the furnace into ingots which may vary from a few pounds in weight for high-alloy steels to 25 tons or more for sheet and plate rolling.

Having obtained an ingot of a suitable size, it is rolled into sheet, strip, plate, bar or sections in a suitable rolling mill. Irrespective of the type of rolling, the actual housing designs are almost identical and it is in different arrangements of a number of rolling-mill stands and different roll arrangements in each stand that the mills vary. In general, most mill housings are of the form shown in Fig. 18 and this has persisted with little change since the very early days of rolling. It provides slides to carry the roll-bearing chocks and a screw-down system for applying load to the rolls.

When rolling from an ingot into sheet, strip or plate, it is usual to roll the ingot down to a slab of suitable width for the finished product and of a thickness which can be finally reduced to the finished gauge, giving the correct metallurgical properties. This first breaking-down process from ingot to slab is usually carried out in a slabbing or cogging mill, mill, which consists of a pair of rolls and a screw-down arrangement which allows a high lift of the rolls to accommodate a wide slab on edge. One, two or three grooves are often cut in these rolls to

Fig. 18.—A typical rolling-mill housing. This particular housing is for a large 4-high mill with rolls 24 in. and 56 in. dia. and 88 in. barrel

[Courtesy of W. H. A. Robertson and Co. Ltd.



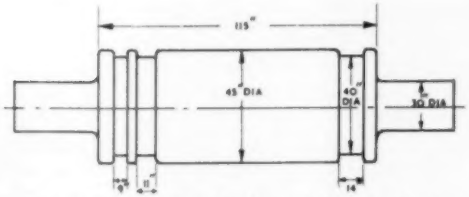


Fig. 19.—Typical roll, with three edging holes, for large slabbing mill

allow the edge of the slab to be rolled square and accurate, as shown in Fig. 19. More than one groove is necessary, as the slab may be turned from side to edge two or three times during the process of reduction depending on the size of the ingot and finished slab. A typical rolling schedule is to bring the ingot on edge, bottom first, to the mill and give it one relatively light pass to clear scale and fins, followed by perhaps two heavier passes to bring it down to somewhere near the finished width. It is then turned to the flat and given several passes to reduce it to perhaps 14 in. thick. Turning back on edge, it is given one or two passes through the 14-in. edging hole to square the edges and reduce the spread to give approximately the correct width. The slab is again dropped on to the flat and rolled down to say 11 in., after which it is turned on edge and given a pass through the 11-in. edging hole to bring the width back as required and to square the edges of the slab. Again it is brought on to the flat and rolled down almost to the finished thickness, turned on edge and passed through the 9-in. hole to obtain the correct width and given a final pass on the flat to give the finished thickness. This procedure is necessary to obtain an accurately shaped slab, but in high production rolling, it is sometimes necessary to sacrifice a little in slab shape to obtain the output, in which case the slab may be only turned on edge twice. Fig. 20 is a photograph of a modern high-lift, high-output slabbing mill, capable of rolling slabs up to 72 in. wide, with an output of 45,000 tons per week. The modern practice, however, is to use a universal mill when very high production is required. In this type of mill, horizontal rolls are used to roll down the ingot to the slab, as in the slabbing mill, but vertical rolls are also used to control the width of the slab at the same time as the thickness is being reduced. The ingot is delivered to the mill on edge, bottom first, as for the slabbing mill, but after two or three passes to give the approximate finished width, it is turned to the flat and rolled down directly to the finished thickness, the vertical rolls being used to control the width. Fig. 21 is a photograph of a modern universal mill capable of producing over 60,000 tons of steel per week.

For plate production, slabs up to 12 in. or 14 in. thick may be required and they are rolled down into plates varying from a fraction of an inch to several inches in thickness. The most common type of plate mill, which is now dying out, is a simple reversing 2-high mill which breaks down the slab part way to the finished gauge, followed by a higher speed finishing reversing mill. This is economical in rolls, as the breaking-down or roughing mill does not require a high degree of smoothness of the roll surface and the finished slab surface is controlled by the second mill, in which the rolls are changed more frequently. The surface quality of the plates from a mill of this type is not high and cannot compare with that obtained from a semi-continuous or continuous mill. In common with most types of rolling, the tendency is now to change to four-high mills to obtain a greater accuracy in gauge and a more consistent product. In order to cope with the increasing demand for plates of all types, the semi-continuous mill is becoming the standard method of rolling. In this the slab is rolled down in a large 2-high or 4-high reversing mill, after which it passes through a train of three or four 4-high finishing mills. This speeds up the process considerably, as only one pass through the finishing mills is required and perhaps three passes through the reversing mill. The time of rolling in the reversing mill can be made to balance the time of the single pass through the finishing mills as, of

Fig. 20.—A large modern high-lift slabbing mill, rolling slabs up to 72 in. wide

[Courtesy of Steel Co. of Wales Ltd.

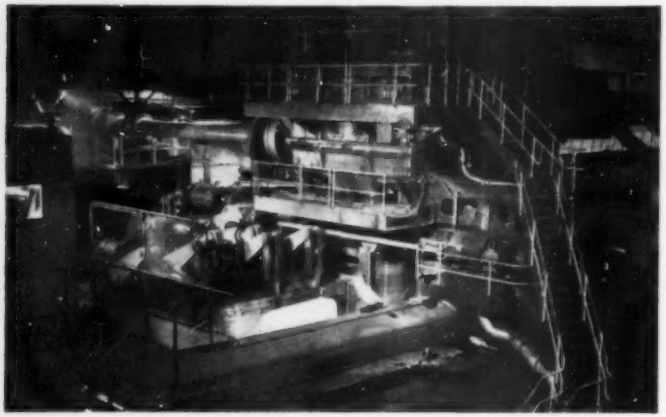


Fig. 21.—A modern high-production universal mill showing the vertical rolls

[Courtesy of Steel Co. of Wales Ltd.

course, the slab will be much shorter in the roughing mill than it is in the finishing train. A very high degree of surface finish can be obtained on the plates as the rolls in the finishing stand can be changed as often as desired. For maximum production of plate a fully continuous mill is required in which a roughing train of perhaps three mills is used, followed by a finishing train of three or four mills. The capital cost of a continuous mill is extremely high and it is unusual to lay one down purely for plate production. It is, however, fairly common for the lighter plates to be rolled on a continuous strip mill.

In the rolling of sheets, a similar process is carried out except that the slab is reduced to gauges in the order of $\frac{1}{10}$ in. and coiled before further processing. Again, layouts, similar to those for plate mills can be used, allowing for the greater reduction which necessitates a greater number of passes in a semi-continuous reversing mill or more stands in a continuous mill. It is usual now, in a continuous strip mill rolling a slab from 6 in. to 8 in. thick down to 0.080 in. to 0.125 in. thick, to have four roughing mills and six finishing stands. Fig. 22 is a photograph of a modern strip mill, rolling up to 72 in. wide with an output of 50,000 tons per week. Narrower mills are more or less a scaled-down version of this. Virtually, all hot-rolled coil is now rolled on semi-continuous or continuous strip mills, but for relatively low outputs, interest is again being shown in the single-stand Steckel mill. This is a reversing mill in which the coil is wound on a reel at each side of the mill, as in cold rolling, but in order to maintain the correct rolling temperature, the coilers are each surrounded by a furnace. This type of mill was first used many years ago and was popular for a short time, but went into disuse, probably because of the high heating costs. In the modern version of this mill with modern furnace techniques, the cost per ton of heating the coil is being reduced and it is again becoming a possible method of obtaining relatively low tonnages of alloy strip.

The surface finish of hot-rolled strip from a continuous mill can be extremely good and it is now becoming common to make many fabricated components from hot-rolled, rather than cold-rolled sheet. For example, motor-car chassis members, brake back plates and similar heavy-gauge sheet articles are now often made from hot-rolled sheet. There is, however, a continually increasing demand for all gauges of cold-reduced sheet and strip and the wide range of qualities and alloys make it necessary to make use of a much greater variety of mills for cold reduction.

The simplest type of cold-reduction mill is a non-reversing 2-high mill, in which hot-rolled coil is passed through the mill, recoiled and returned for

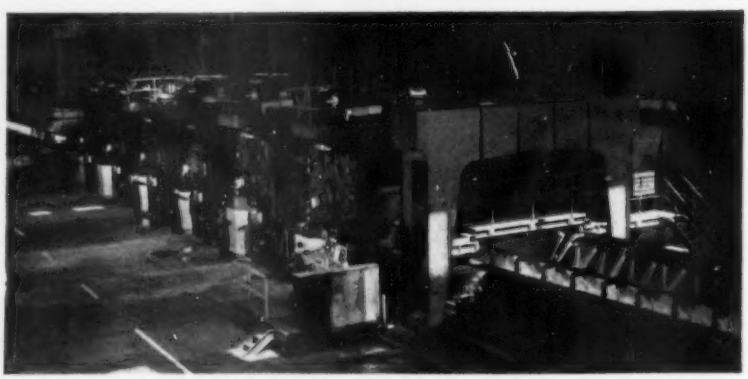
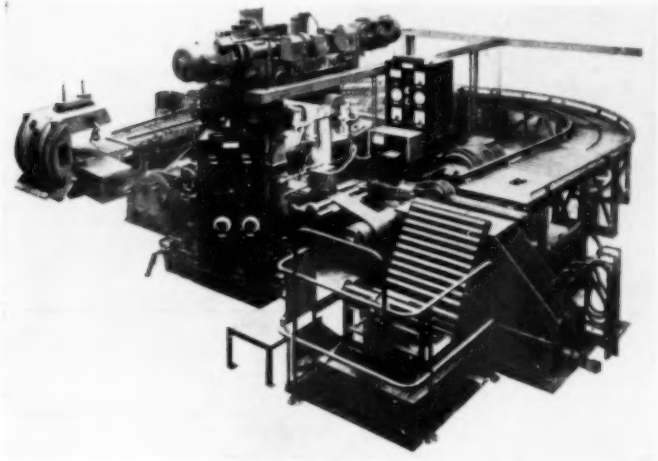


Fig. 22.—The finishing stands of a modern wide strip mill, capable of rolling almost 50,000 tons per week

[Courtesy of Steel Co. of Wales Ltd.



[Courtesy of W. H. A. Robertson and Co. Ltd.

Fig. 23 (above).—Modern non-reversing 4-high mill

Fig. 24 (right).—Small hand-turned jewellers' mill

[Courtesy of W. H. A. Robertson and Co. Ltd.

further passes, until the final gauge is obtained. This is a slow process and this type of mill is virtually obsolete, although there are a few modern versions still being built. One of these, used for rolling brass strip, is shown in Fig. 23. A coil is passed through the mill, recoiled and transferred to a conveyor which carries the coil back to the front of the mill for the next pass. When rolling large tonnages of an identical gauge and size, so that there is a constant stream of coils being transferred round the conveyor, this mill is worthy of consideration, as the electrical equipment, which now often costs more than the mill, can be simplified and built much more cheaply. For rolling very

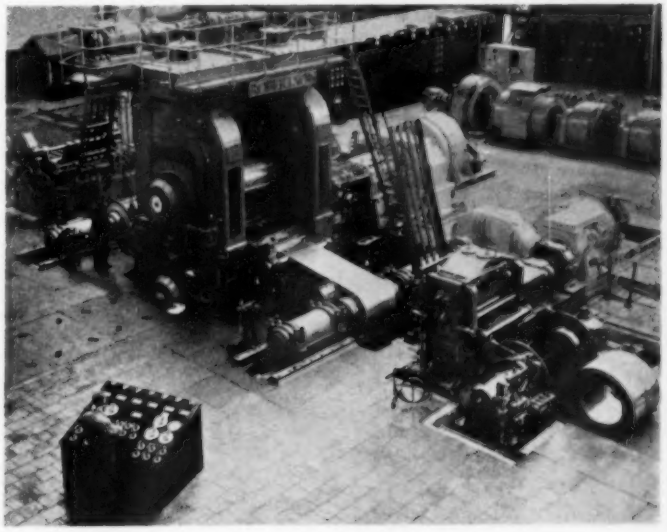


Fig. 25.—Large reversing 4-high mill rolling stainless steel

[Courtesy of W. H. A. Robertson and Co. Ltd.

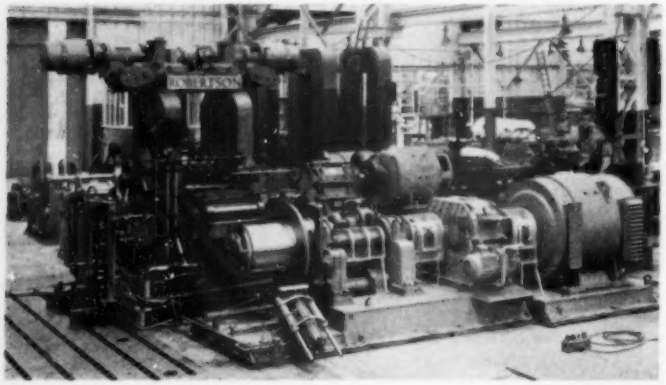


Fig. 26.—A typical small 4-high reversing mill shown in the manufacturer's workshop before delivery

[Courtesy of W. H. A. Robertson and Co. Ltd.

small quantities of narrow material, the simple 2-high mill is still popular as represented by the jeweller's mill, shown in Fig. 24.

The reversing 2-high or 4-high single-stand mill is perhaps the most common of all and has maintained its supremacy for many years. In the reversing mill, the coil is passed backwards and forwards through the mill from one reel to the other until the required gauge is reached. It has the advantage of being extremely versatile in that a wide range of gauges can be rolled from a range of hot mill band gauges, simply by varying the number of passes through the mill. It is also possible to maintain an accurate gauge, as adjustments can be made on each pass, so that on the final pass it is relatively easy to maintain the gauge constant and accurate.

The largest single-stand reversing mill in this country has a barrel length of 80 in. and rolls sheet, particularly for car-body work up to 72 in. wide. Fig. 25 shows a reversing mill a little smaller than this, which was built particularly for the rolling of stainless steel. There are comparatively few large reversing mills and by far the greatest number of mills of this type roll strip in the range 6 in. to 18 in. wide. A typical smaller reversing mill is shown in Fig. 26. It may be interesting to mention here that in order to carry out research into the rolling of metal, an experimental single-stand reversing mill was built for the British Iron and Steel Research Association and although it is representative of a normal production mill, it has various interesting modifications. For example, arrangements were made in the design of the mill to enable work-roll diameters to be varied from 3 in. to 7 in. Powerful coiler motors were fitted and the electrical control circuits embodied many of the latest techniques, some of which were still under development. This mill is also fitted with a full range of instruments to record rolling variables, such as screw-down load, drive-spindle torque and strip tensions. This is shown in Fig. 27.

The development in cold rolling has been similar to that in hot rolling and in order to obtain the very high outputs required under modern

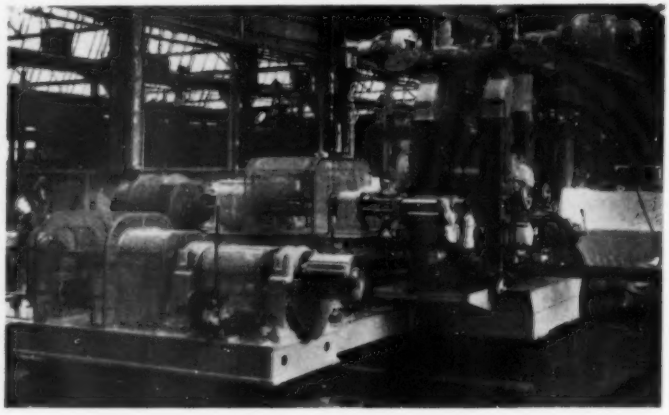


Fig. 27.—The BISRA mill shown in the manufacturer's workshop. The unusually large gap left under the screws for provision of load-meters can be seen

[Courtesy of W. H. A. Robertson and Co. Ltd.

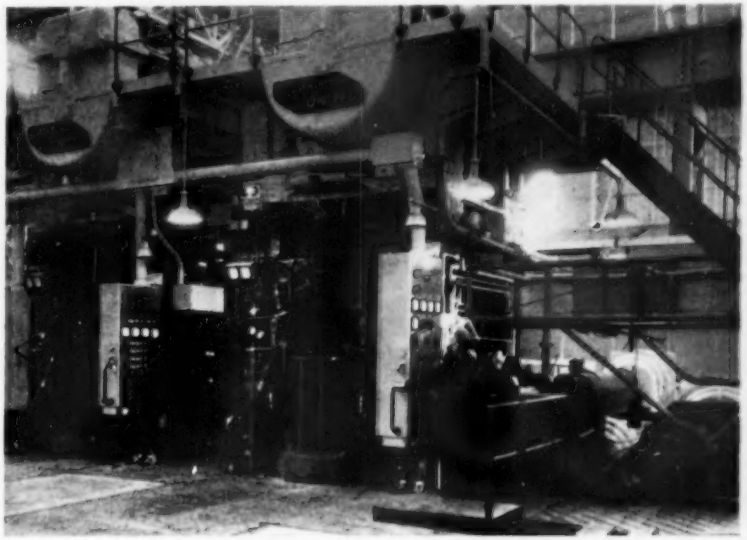


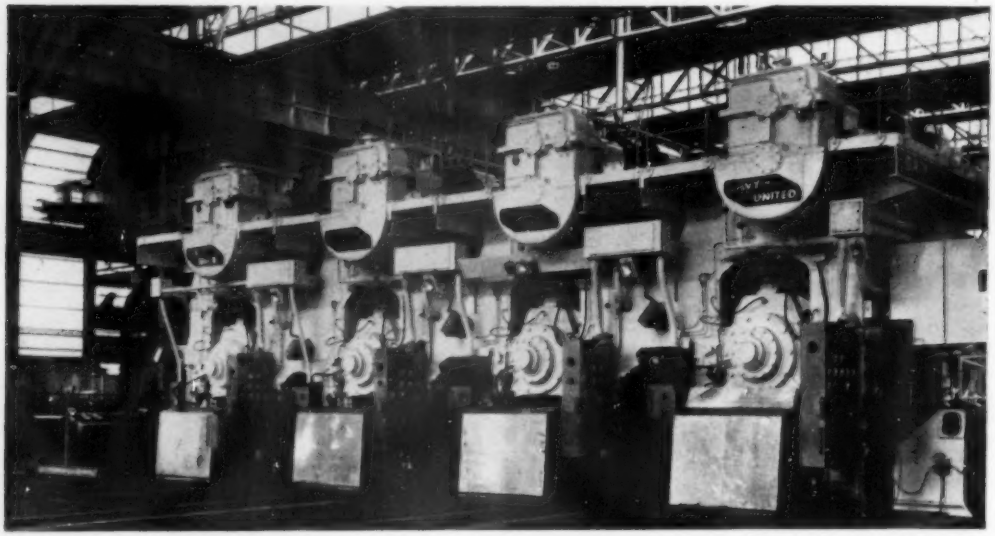
Fig. 28 (right).—A typical two-stand high-speed temper mill (Davy-United)

[Courtesy of Steel Co. of Wales Ltd.

Fig. 29 (below).—Modern high-speed 5-stand tinplate mill (Davy-United)

[Courtesy of Steel Co. of Wales Ltd.

conditions, more use is being made of the multi stand continuous mill. The simplest form of continuous mill consists of two single-stand non-reversing mills set in line with each other, with the coil feeding from the roll through both mills and rewinding. At first these mills were placed at some considerable distance apart and the strip allowed to loop between them. It was quickly found, however, that application of tension between the mills helped considerably in obtaining gauge and maintaining good shape in the rolled material, but this complicated the control of the mill to some extent and the problem is discussed in a later chapter. Control of the mill was improved by placing the mill stands as close together as was reasonably possible and modern technique is to allow just sufficient room between stands for a man to enter to feed the mill or to remove scrap. The



[Courtesy of Steel Co. of Wales Ltd.

Fig. 30.—Modern high-speed 4-stand tandem mill (Davy-United)

2-stand mill is not very common to-day, as the reduction obtained in the two stands is not sufficient for the metallurgical properties required in most cold rolled sheet. It is, however, the standard arrangement for temper-rolling tinplate sheet, when it is common to have one stand with bright rolls and one stand with shot blasted rolls, to give a roughened surface on the rolled sheet. A typical 2-stand temper mill is shown in Fig. 28.

Perhaps the most common tandem mill is the 3-stand mill and a common overall reduction from the hot band in a mill of this type is 50 per cent to 70 per cent. Again the biggest mill in this country has a barrel length of 80 in. and rolls sheet up to 72 in. wide, particularly for car-body work. For rolling large quantities of tinplate, the 5-stand tandem mill has become standard and it is usual to roll from a hot band gauge of 0.070 in. to 0.084 in. down to tinplate gauges from 0.007 in. to 0.012 in. A typical modern tinplate mill with a finished speed of 4,000 ft. per minute is shown in Fig. 29. It has been suggested that as the market for the lighter

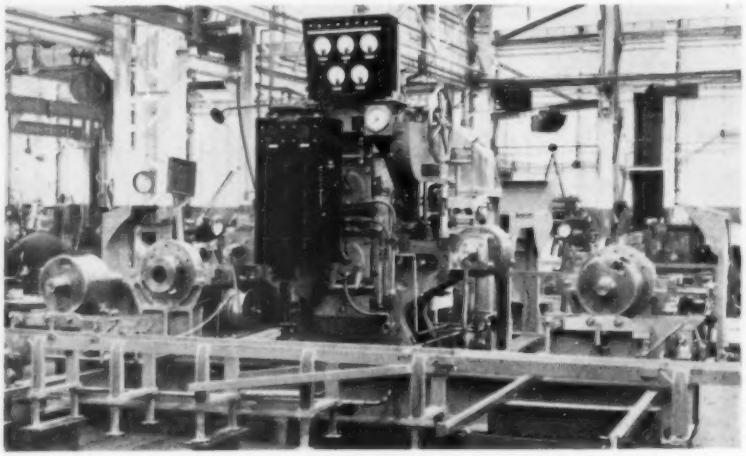


Fig. 31.—A C.M.P. 4-high driven back-up-roll mill

[Courtesy of W. H. A. Robertson and Co. Ltd.

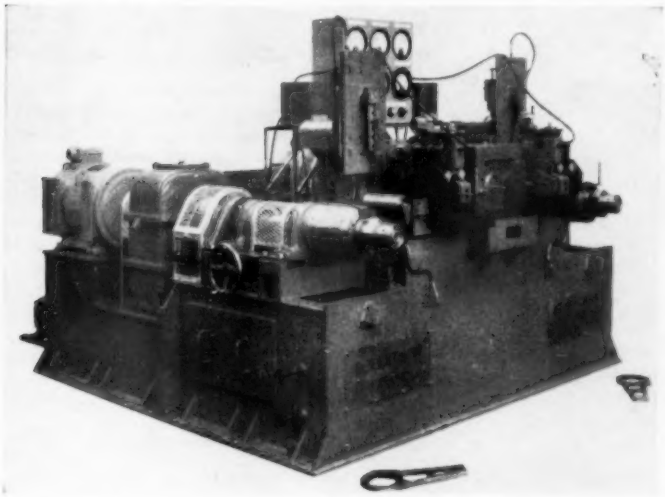


Fig. 32.—Small Sendzimir mill with a 1, 2, 3 roll arrangement

[Courtesy of W. H. A. Robertson and Co. Ltd.

gauges of tinplate increases, it may be necessary to use a 6-stand mill. This, however, is not the real answer, as there is a minimum thickness which can be rolled economically on a given size of work roll and adding a further stand will not necessarily reduce the possible finished gauge. It would, however, enable a heavier hot-mill band gauge to be used for rolling normal tinplate gauges and so help to increase the hot-mill outputs.

The tandem mill which is coming into prominence for a wide variety of rolling, is the 4-stand. This will tackle anything from sheet to the heavier tinplate gauges and a modern example is shown in Fig. 30. When rolling sheet with a shot-blast finish on the last stand, an overall reduction of 75 per cent is quite within its capacity and with a little care in operating, it is possible to go as low as 50 per cent. This, therefore, covers the range of most cold-rolled sheet requirements. By using bright rolls in all stands and a suitable rolling oil,

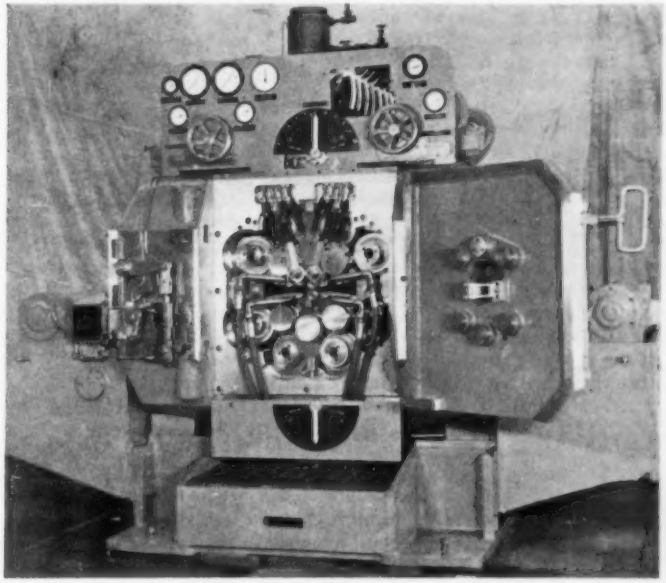


Fig. 33.—A Sendzimir mill with a 1, 2, 3, 4 roll arrangement. The mill stand only is shown, with no coiling equipment

[Courtesy of W. H. A. Robertson and Co. Ltd.

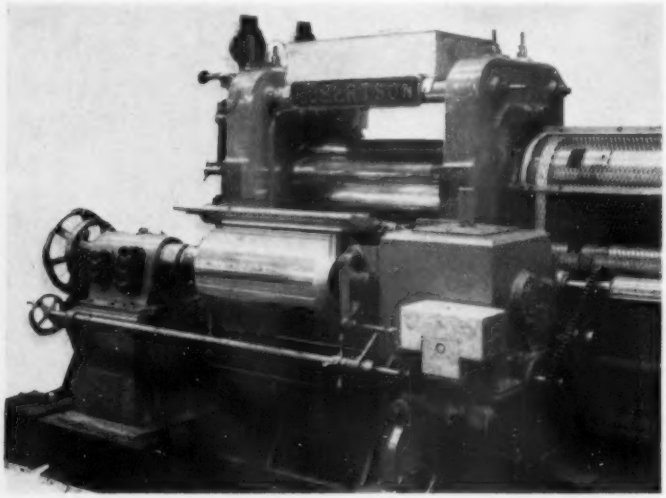


Fig. 34 (left).—A 2-high mill for rolling aluminium foil, with hydraulic roll loading

[Courtesy of W. H. A. Robertson and Co. Ltd.

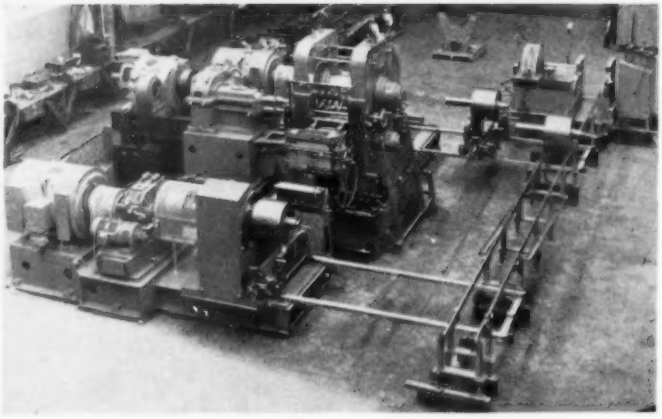


Fig. 35 (below).—A small hydraulically loaded 4-high mill. The jacks are below the bottom chocks

[Courtesy of W. H. A. Robertson and Co. Ltd.

it is possible to roll tinplate gauges down to 0.012 in. and even less than this if some little drop in output can be tolerated. This mill is becoming so popular that some 3-stand mills are being converted to 4-stand, because of this flexibility in the type of orders which can be rolled. There is, however, a considerable problem in selecting the rolling oil for a 4-stand mill, as to date there is no single oil which can be used to roll all the different gauges which can be put on this type of mill.

Although the main trend in recent years has been in the high production of various grades of drawing steel, there is still a considerable market for alloy steels, foil and light gauge strip. These all require special mills for cold reduction.

It is well known that for rolling light gauges, particularly in hard alloys, the smaller the work roll, the easier it is to roll and the less power is required. The reason for this is discussed in the next chapter. The tendency has been, therefore, to reduce the size of the work roll as far as possible. In the normal 4-high mill there is a practical limit on reducing the work-roll diameter, as the drive is taken through the work-roll neck and it must be sufficiently strong to stand the torque, bending and shock loads. One development of a 4-high mill which is becoming popular, is that in which the back-up rolls are driven and the work rolls driven by friction only from the back-up rolls. The limit on the minimum work-roll size in this case is the resistance of the work roll to lateral bending. This mill is usually reversing, with very heavy tensions and is used for reducing strip to light gauges, perhaps in the order of 0.003 in. to 0.005 in. By using a small-diameter work roll, it is possible to obtain the required reductions with the minimum number of stops for intermediate annealing. The patents for this type of mill are held by the Cold Metal Products Company and an example of one of their mills built under licence by W. H. A. Robertson and Co., Ltd., is shown in Fig. 31. Another type of mill which is becoming very popular for the rolling of light gauges in hard alloys is the Sendzimir, which uses the smallest

(*Continued in page* 765)

The Rolling of Metals

(*Continued from page* 764)

possible work-roll diameter with a large number as backing rolls. In some cases the work roll is of little as $\frac{1}{2}$ in. in diameter and each work is backed up by two backing rolls, which in turn are backed up by three rolls, which have bearings supporting them against the mill housing. An example of a small Sendzimir mill is shown in Fig. 32, and it will be seen that the mill is a very small unit compared to the coiling and uncoiling equipment. A larger Sendzimir mill is shown in Fig. 33 and it will be seen from the photograph that each work roll is backed up by two backing rolls, which in turn are backed up by three and subsequently four rolls, which run on bearings against the mill housing. This type of mill is particularly useful and is finding a great deal of use in the rolling of rapidly work-hardening alloys, such as stainless steel, where high reductions can be obtained without annealing. Extremely high strip tensions are used when rolling with a Sendzimir mill to reduce the vertical load on the rolls; any horizontal load on the rolls is not very important, as the backing rolls give some lateral as well as vertical support to the work rolls. It has been mentioned that in general the lighter the gauge being rolled, the smaller should be the work-roll diameter, but it is interesting to note that mills for rolling aluminium foil are in contrast to this. It is almost universal for aluminium foil mills to be 2-high mills, with a high barrel length to diameter ratio. An example of a modern foil mill is shown in Fig. 34.

In the foregoing it has been assumed that all the mills have a conventional mechanical screwdown arrangement which has been developed from the old-type mills, which started with simple wedge adjustments. In order to obtain the fast response to changes in roll load required for automatic correction of gauge, it is probable that hydraulic loading will come rapidly to the fore in the next few years. Simple hydraulically loaded mills have been in use for some years and Fig. 35 shows an example of a small 4-high mill with simple hydraulic loading jacks.

Most materials after cold reduction become too hard and brittle to be of any practical value and it is usual to anneal to soften the steel and follow this by a temper rolling process which gives just sufficient reduction to obtain the ductility required. For temper rolling it is usual to use a 4-high non-reversing mill, but as mentioned earlier, for tinplate it is often necessary to use a two stand tandem mill to obtain the temper reduction required and give a shot blast finish.

The actual operating techniques of the various types of mill are discussed later.

(*Series to be continued*)

Press Tools

(*Continued from page* 741)

An interesting job which disproves the statement of many people, that the double-action press is useless for anything but deep drawing, is shown in Fig. 25.

This is an article made in a single stroke of a double-action press. It includes the operations of bending, stretch-forming, drawing, piercing and plunging. The tools used to produce the part shown are illustrated in Fig. 26. The sheared blank is placed in the swinging locators and on descent of the blankholder it is formed into a " U " shape, over the semi-circular die form, and the centre is partially formed into the recess in the blankholder. The plunger slide next descends and the punch completes the centre depression by a combination of drawing and stretch forming.

In the centre of the drawing punch a piercing punch is mounted and, as the punch touches bottom dead-centre, air is admitted to the cushion to drive the combined piercing and plunging punch upwards to pierce out a slug and plunge-up the flange around the centre hole.

The development of this tool presented several problems of an unusual nature, among which was the large clearance between the inner and outer slides, a common feature on all drawing presses, to allow for some degree of self-centring of the punch. This was an undesirable feature for the tool in question as a cutting operation was included. The solution was to machine away the inner slide and fit an adjustable gib-strip, as is normal machine-tool practice.

GAUGE AND TOOL AND POWER-PRESS EXHIBITION, 1962

THE list of definite applications for space at the next Gauge and Tool and Power Press Exhibition, which will be held from October 1 to 10, 1962, has now been closed. Firmly booked space amounts to 52,000 square feet, compared with a total of 42,900 square feet in 1958, and the National Hall at Olympia, London, will be filled to capacity.

CONTINUOUS PICKLING OF SILICON-STEEL STRIP

A Description of Plant at the Brierley Hill Works of

RICHARD THOMAS AND BALDWINS LTD.

DURING the last two years, Richard Thomas and Baldwins Ltd. have been producing high-quality silicon steel strip at their Brierley Hill Works, near Birmingham. The following describes the continuous pickling lines of this installation.

The pickling section of the strip lines was designed and manufactured by the Kestner Evaporator and Engineering Co. Ltd., London, in close collaboration with the Engineering Division of Richard Thomas and Baldwins, Ltd. and comprises two continuous lines handling two sizes of strip. A third section is to be incorporated to pickle the steel strip after shotblasting treatment prior to the cold reduction stage. This line will differ considerably from the two lines already installed since pickling will be carried out by a spray system followed by a high-efficiency wash unit of a unique type.

The two strip lines already installed are similar in design but vary in length and certain basic features. The first line comprises two 50-ft. long pickle tanks preceded by a pre-scrubber tank. The pickle section is followed by two spray wash tanks and an electrically-heated air dryer. The acid used in the pickle tanks is a mixed sulphuric and hydrofluoric acid and the strip passes under tension beneath a series of ducking rollers which keep the strip immersed in the acid. During its passage through the wash section, the strip passes between spray pipes which wash off the residue carry-over acid. A series of 12-in. dia. rubber-covered mild-steel wringing-rollers remove the pickle acid after the strip exits from the pickle tank and similar rollers are fitted after the wash section. The design of the wringer-rollers is of a special type, pressure being maintained by air. The wringing pressure can be varied by adjusting air control valves.

In the pickle section, rubber-covered mild-steel ducking-rollers hold the strip under the acid and, to assist threading, these rollers can be operated by electric motors to raise them above the strip-line height. The design of the rollers and the raising and lowering gear is of a special type and the complete operating gear is shrouded to prevent contamination by pickle acid. A particular design feature of the strip lines is that they are arranged for a minimum consumption of wash water. The wash tanks are connected in series and the water

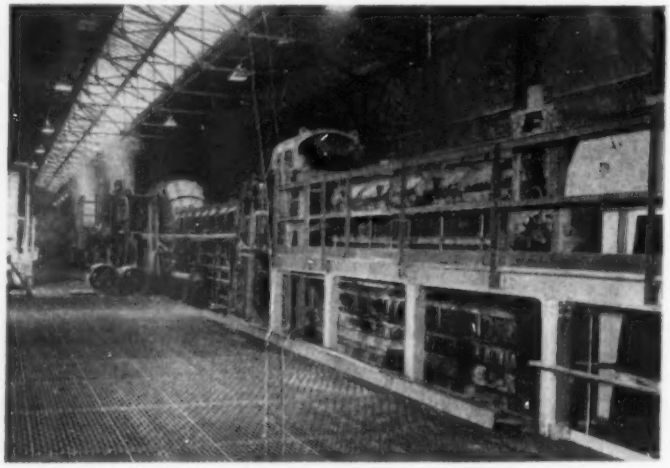


Fig. 1—Two Keebush pickling tanks in series, and right the wash tanks

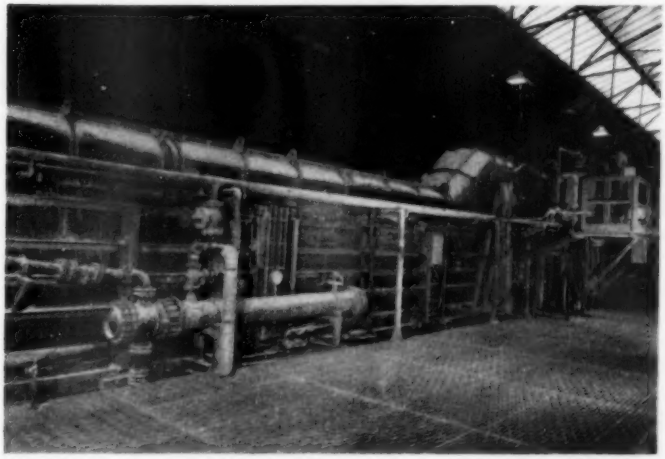


Fig. 2 (left).—A pickling tank with acid heater in the foreground and acid make up the tanks on the right

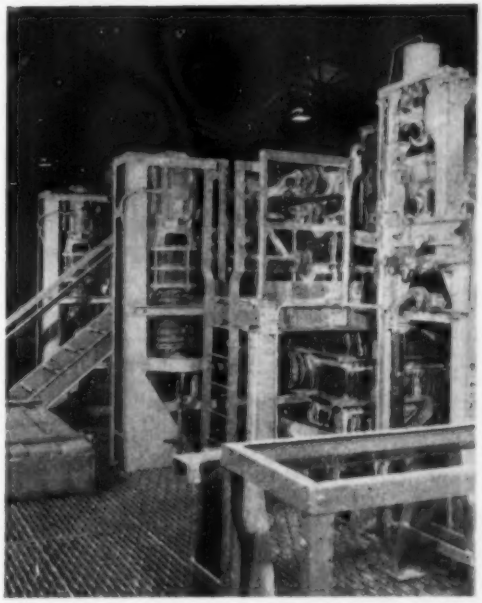
Fig. 3 (below).—Acid circulating pumps of the wash tanks

flows counter-current to the strip, from the end wash tanks to the pre-scrubber tank. In the washing process the wash water becomes slightly acidified due to acid carryover and it flows by gravity to the pre-scrubber tank, where it is sprayed on to the strip. In this way a partial pre-pickle spray treatment is given to the strip prior to entering the main pickle tank section. The necessary make-up of wash water is added to the last wash tank in the line.

The complete pickle plant comprising pickle tanks, covers, wash tanks and pre-scrubber tanks are manufactured in Keebush material, chosen for its high resistance to the corrosive effects of the mixed sulphuric-hydrofluoric acid. Heating of the pickle tanks is carried out by Keebush/Keebon external acid heaters and the necessary circulation through the heaters is provided by Keebush vertical glandless pumps. The heaters are of multi-tube horizontal type, provided with floating end-tube plate assemblies to counteract expansion effects. Steam for the heaters is provided at a pressure of 25 p.s.i.g.

An important requirement of the plant is that of high-efficiency fume extraction. This is provided by Keebush 24-in. axial flow fans and suitable ducting. Offtakes are provided in the pickle tank covers which lead to the fan and chimney system. Preceding the fans Calder Fox scrubbers are fitted which remove particles of entrained acid in the vapour stream. By this means the acid in the vapour is reduced to a minimum and the vapours can be discharged through the Keebush stacks to atmosphere, without further wet scrubbing treatment.

A unique feature of the plant is the wash water effluent arrangement. The wash waters are neutralized continuously in a neutralizer of special design.



The neutralizing media is a 10 per cent milk of lime solution which is made up in two mixing tanks each of 2,000 gal. capacity. This solution is made up and pumped through a ring main system to the neutralizers, which are situated some 300 ft. away adjacent to the pickle lines. The lime is delivered to the works in 20-ton loads and is stored in a 20-ton silo, sited adjacent to the lime mixing tanks. The lime, in controlled quantities, is transferred from the silo to the mixing vessels where the

(*Continued in page* 768)

Strip Pickle Plant

(*Continued from page 767*)

Fig. 4.—Centralized control panel for the pickle line

appropriate strength of solution can be made up.

Bulk acid storage is provided by two 12-ton horizontal cylindrical mild-steel tanks for the 76 per cent sulphuric acid, and two similar tanks for 20 tons of 83 per cent hydrofluoric acid. These acids are delivered by road tankers, and pumped from the tankers to the storage tanks by compressed air. The acid storage plant is situated some 300 ft. from the pickle lines and acid is transferred from the storage tanks to the pickle lines by a suitable pipework and pump system. Lead pipes and pumps are provided for the sulphuric acid and the hydrofluoric acid system is handled in mild-steel and polythene pipes. Adjacent to each pickle line is an acid measuring tank, one for each acid, 3 ft. in diameter by 3 ft. deep from which the required quantity of acid is transferred to the pickle tanks.

An unusual feature of the hydrofluoric installation is that venting of the stock tanks and measuring vessels is carried out by a pipework system to the pickle tank covers. This eliminates having a separate venting system with scrubbing towers.

Control of the pickle line is effected from a central panel adjacent to the line which houses all the starting equipment for the various pumps and motors. Adjacent to the motors of the pumps and other items, are fitted local push buttons, and warning lights on the electrical equipment are also incorporated.

Due to the siting of the acid storage and lime mixing vessels some 300 ft. away from the pickle lines, a separate control system is provided for these. This is situated adjacent to the acid storage section in a small building, which houses the lime mixing tanks and weighing equipment.

The second pickle line is very similar to that described above with the exception that a pickle section of 30 ft. length only is provided. This line is served by the central acid storage and line system described above.

It is not possible to specify in detail the steel production from this line since it is continually increasing to keep pace with the increased usage of high quality strip. Nominal line speeds are 130 ft. and 150 ft. per min., but it is possible to increase these speeds considerably to raise the strip output.

INTERNATIONAL METALLIC CORROSION CONGRESS

THE provisional programme of the above Congress, which will be opened on April 10, 1961, by the President, Sir Harry Melville, K.C.B., D.Sc., F.R.I.C., F.R.S., has now been announced. Plenary lectures are to be given by Prof. Y. M. Kolotyrkin (U.S.S.R.)., Prof. P. Lacombe (France), Prof. H. H. Uhlig (U.S.A.), and Dr. U. R. Evans (U.K.). The Congress will include technical sessions and visits to laboratories and industrial organizations, and an attractive ladies' programme is being arranged. The following have accepted vice-presidencies of the Congress: Prof. G. Chaudron (France), Prof. W. Feitknecht (Switzerland), Dr. H. P. Godard (Canada), Dr. F. L. LaQue (U.S.A.), Prof. R. Piontelli (Italy), Dr. M. Pourbaix (Belgium), Dr. F. N. Speller (U.S.A.), Prof. N. D. Tomashov (U.S.S.R.), Dr. W. H. J. Vernon, O.B.E. (U.K.), and Prof. K. Wagner (Germany).

10

SHEET METAL DATA SHEET

Manipulation of Angle Iron

Compiled by J. W. Langton, M.B.E., B.Sc.(Lond.), M.I.Mech.E.

MANIPULATION OF ANGLE IRON

ANGLE iron in particular, and rolled sections in general, are often used in conjunction with sheet metal in various fabrications. This data sheet is intended to cover some of the standard methods of manipulating angle iron for these purposes. The principles described will serve in the main for tee and channel iron and similar sections but the emphasis here is on the main requirements using angles.

CUTTING

The general common methods available for cutting angle iron are (*a*) shearing (*b*) abrasive wheel machines (*c*) cold saws, leaving out the elementary hack saw and the band saw.

SHEARING

Cutting by shearing is the quickest of the three methods, and it may be the cheapest production method. The shearing is done in dies shaped to suit the section, which are usually mounted in some form of angle-iron-shearing machine. The only main reason why the other methods are considered is due to the quality of the cut, as there is always some distortion or risk of distortion on one of the cut edges. This can be overcome by reinsertion of the portion with the distorted edge in the opposite direction and the cutting off then of a small width of cut, if necessary.

While the principle used in practically all angle shearing machines is the same, the application may be a little different, so it may be found that some machines give a better quality cut than others.

Angle Shearing Machines

Angle shearing machines may be obtained for hand or power operation, the hand range giving up to $3 \times 3 \times \frac{3}{8}$ and the main power range up to $7 \times 7 \times \frac{3}{8}$. While machines can be obtained for the shearing work only, there is a tendency to offer machines capable of carrying out other operations on the angles besides shearing. This is less likely in the hand-operated range where it should be appreciated that a fair manual effort is required to shear, say, $2 \times 2 \times \frac{1}{4}$. However, machines are available in the hand range to: (*a*) shear only (*b*) to shear and notch (*c*) in addition to shear rounds, squares and flats (*d*) to shear, notch and punch. In addition, three separate units, to shear, to notch and to bend can be obtained mounted in a common stand.

A possible variation to consider in all machines is the need for provision for mitre cutting. Some hand machines, but certainly not all, are so arranged, but most power-driven machines are.

Power machines for shearing only are usually arranged to cope with most standard sections, by provision of extra blades where necessary. A medium-size machine would take up to 4-in. angles and 2-in. bars. Single-purpose shearers of smaller capacity are rather unusual. Strokes per minute of such machines about 30 to 35. For shearing only smaller sections, use of shearing tool in power press can be considered.

Power machines for combined operations are usually (*a*) punching and shearing machines (*b*) punching, shearing, notching machines, the shearing including not only section shearing but plate shearing and round and square bar shearing, *i.e.* at least for operational stages. Strokes of the combined machines are again about 30 per minute.

Abrasive Wheel Cutting

There are many machines available using the same principle. The cutting may be dry or wet. Wet cutting with resinoid bonded wheels requires greater power than

10 SHEET METAL DATA SHEET

Manipulation of Angle Iron (Cont.)

dry cutting, gives a rougher cut, but does give longer wheel life. Rubber-bonded wheels must be used wet and the finish is greatly improved but the wheel life is down a little against dry cutting with resinoid wheels. However, rubber-bonded wheels are not popular because of the smell and fumes.

The life of an abrasive wheel can vary considerably between firm and firm and operator and operator, but drops as the standard of finish required rises. The latter is due to the need to use softer wheels.

In selecting a machine, choose one with ample power.

Some approximate data on cutting times and wheel life for some common sizes of angles is given as follows:

$3 \times 3 \times \frac{3}{8}$— Approx. time for ten cuts floor to floor is 2 minutes.
Approx. number cuts per wheel, 110.

$2 \times 2 \times \frac{1}{4}$— Approx. time for ten cuts floor to floor, 1 minute.
Approx. number cuts per wheel, 300.

$1\frac{1}{2} \times 1\frac{1}{2} \times \frac{1}{4}$—Approx. time for ten cuts floor to floor, 50 seconds.
Approx. number cuts per wheel, 400.

These figures are for dry cutting. Wet cutting would be a little slower, but would give much increased wheel life. The tests were made on a new $16 \times \frac{1}{2}$ wheel. Approximate cost 20s.

Cold Sawing

Where there is a tendency towards heavier sections and angles, the cold saw may be preferred to the abrasive wheel. The life of a saw blade is much higher than that of the abrasive wheel machine and of course it may be re-ground.

It is difficult to make exact floor-to-floor comparisons with the abrasive wheel, because of the varying ranges of the machines available. The cold saws tend to be made to suit the cutting of heavier sections, the abrasive wheel the lighter, but there is a definite tendency for the cold saw to be the quicker of the two.

The selection from abrasive wheel versus cold saw is one for experience; deciding on the basic circumstances of the particular cutting problem. Particularly if the quantities to be dealt with are medium to large, advice should be sought.

NOTCHING

Angle iron has to be notched generally in order to permit it to be bent, and most of the notches are of the Vee notch or the square notch type.

Notching machines can be obtained for hand or power operation. In the latter case provision for this operation is usually combined with others, so that where the quantities to be notched are large, power presses are often used for single-purpose work.

BENDING

For bending at right-angles or similar after notching, the standard type of bar bender is used.

ROLLING TO CURVED SHAPES

Angle iron may be rolled to curved shapes or rings in angle-iron or section-rolling machines.

These consist in principle of a set of narrow pyramid bending rolls, open ended. Provision by split roll or similar has to be made to clear the web of the section and very often the angles are rolled back to back.

Handpower machines can be obtained to roll up to $1\frac{1}{2} \times 1\frac{1}{2} \times \frac{1}{4}$ and power machines generally up to $4 \times 4 \times \frac{3}{8}$.

Rolling angles to small radii of curvature is difficult and the minimum diameter to which small sized angles can be rolled is of the order of 20 in. and in medium sizes more like 30 in.

SHEET METAL DATA SHEET 10

Manipulation of Angle Iron (Cont.)

Fig. 1—Cold saw

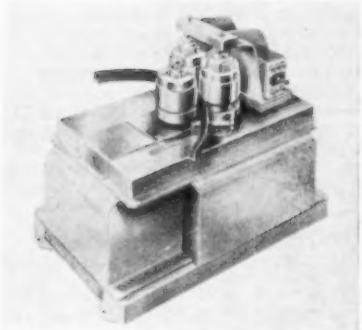


Fig. 2—Angle iron rolling and curving machine

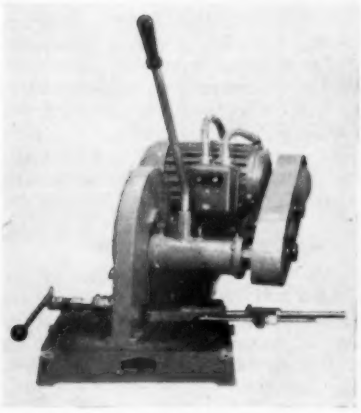
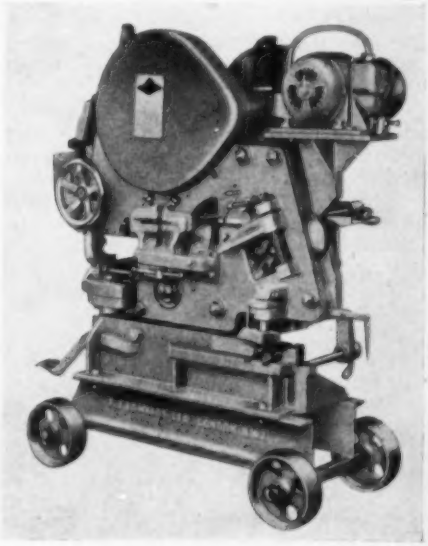


Fig. 3—Abrasive cutting-off machine

Fig. 4—Combined hand power unit for shearing, notching and bending angle

Fig. 5—Power punching, shearing, notching machine



INSTITUTE OF SHEET METAL ENGINEERING

● *Forthcoming Activities*

SPECIAL CONFERENCE ON COLD EXTRUSION OF STEEL

SINCE technical discussion on the production of steel components by a cold extrusion process was initiated in this country at a special conference organized by the Institute in 1953, slow but steady progress has been taking place in the development and application of the process. A number of companies are now operating cold-extrusion processes under licence and a considerable amount of investigational and development work has been carried out, both by private firms and some Government establishments. It has appeared timely that a further opportunity be provided for reviewing the stage in development which has now been reached and discussing some of the findings at a rather more practical level than was possible in 1953, in the light of experience gained since that date.

Details have now been released of the Special Conference on Cold Extrusion of Steel which is to be held in Sheffield on November 21 to 23 next. All technical sessions will be held in the Memorial Hall of the City Hall, Sheffield.

Admission to all Technical Sessions is by TICKET ONLY which are available without charge to Members of the Institute of Sheet Metal Engineering and of the National Association of Drop Forgers and Stampers. Non-members of these bodies are welcome to attend on payment of a registration fee of 3 guineas. Buffet Luncheon will be available on each of the two full meeting days and preprints of the papers will be circulated prior to the Conference to those who apply for them. It is expected that a number of films will be shown during the meeting and facilities are also being provided for the display of exhibits demonstrating applications of the process.

Application forms for tickets for this meeting are available from the Hon. Secretary, Institute of Sheet Metal Engineering, John Adam House, John Adam Street, Adelphi, London, W.C.2.

The full technical programme of the Conference is as follows:

Monday, November 21

2.30 p.m. 1st Technical Session.

Paper—"ECONOMICAL USE OF COLD FORGED COMPONENTS," by Dr. Ing. H. D. Feldmann (Cold Forging Ltd.)
Paper—"EXPERIENCES IN THE INDUSTRIAL PRODUCTION AND USE OF COLD EXTRUDED STEEL COMPONENTS," by R. E. Okell (Forgings and Presswork Ltd.).

Tuesday, November 22

9.30 a.m. 2nd Technical Session.
Paper—"COLD FORMING OF STEELS," by F. Griffiths (British Motor Corporation Ltd.).
Paper—"TOOLS FOR COLD EXTRUSION," by W. S. Ketchin and A. E. Walmsley (Royal Ordnance Factory, Birtley).
Paper—"COLD EXTRUSION OF SMALL SYMMETRICAL AND ASYMMETRICAL PARTS," by Prof. Dr. Ing. O. May (Technische Hochschule, Stuttgart.)

1.00 p.m. Buffet Luncheon.

2.30 p.m. 3rd Technical Session.
Paper—"PRESSURE ECONOMY," by Melvin Verson (Verson Allsteel Press Co. Inc.).
Paper—"DEVELOPMENT AND PRESENT POSITION OF INSTALLATIONS FOR THE MANUFACTURE OF COLD FORGED COMPONENTS," by Dr. Ing. H. D. Feldmann (Cold Forging Ltd.).

Wednesday, November 23

9.30 a.m. 4th Technical Session.
Paper—"AN EXPERIMENTAL INVESTIGATION INTO THE COLD EXTRUSION OF STEEL," by H. Ll. D. Pugh, M. T. Watkins and J. McKenzie (National Engineering Laboratory).
Paper "SOME INVESTIGATIONS INTO THE COLD EXTRUSION OF STEEL," by F. Howard, H. A. J. Dennison and N. S. Angus (Production Engineering Research Association).

1.00 p.m. Buffet Luncheon.

2.30 p.m. 5th Technical Session.
Paper—"PHOSPHATE COATING AND LUBRICATING STEEL FOR COLD EXTRUSION," by D. James (The Pyrene Co. Ltd.).
Paper—"TOOL MATERIALS FOR COLD EXTRUSION," by A. W. F. Comley (Wilmot Breeden Ltd.).

TRIPARTITE CONFERENCE IN 1961

Plans are progressing for the three-cornered meeting to be held in London in May, 1961, between the American Pressed Metal Institute, the German Forschung für Blechverarbeitung and the Institute of Sheet Metal Engineering. Although details have yet to be finalized it is anticipated that the meeting will comprise two half-day sessions at which papers will be presented by representatives of each of the three bodies, outlining developments and operation of the pressworking industries in each of the countries. Arrangements will also be made for the overseas participants in the meeting to visit a number of works in the London and Birmingham areas.

BRANCH PROGRAMMES

The programme card of Branch meetings for the 1960/61 session has now been issued. Non-members interested in Branch activities can obtain one of the limited number of additional copies available on application to Branch Secretaries or to the Hon. Secretary of the Institute.

SHEET METAL NEWS

FEATURING EVENTS AND PERSONALITIES IN THE INDUSTRY

NORTHERN ALUMINIUM CHANGES NAME

Clearer Identification With Aluminium Ltd. of Canada

THE Northern Aluminium Co. Ltd., has changed its title to Alcan Industries Ltd. This new name involves no change of ownership, manufacturing activity or sales policy. Its purpose is simply to identify the company clearly as a member of the Aluminium Ltd. of Canada enterprise—"Alcan" for short.

Aluminium Ltd., with headquarters in Canada comprises some 50 companies in more than 25 different countries, engaged in all phases of aluminium production and marketing, but the heart of the business is the use of Canada's hydro-electric power resources for the efficient smelting of the bauxite mined in the tropical countries. The company's gross fixed assets exceed $1,400,000,000 and the integrated operations they represent include the mining of bauxite and other ores on four continents; the generation of hydro-electric power; the smelting of aluminium in six countries; and the fabrication in more than 20 countries of some of the ingot into forms useful to industry. Aluminium Ltd. has sales outlets in 114 countries.

Northern Aluminium Co. Ltd. was incorporated more than 50 years ago and is Aluminium Ltd.'s principal fabricating company, converting Alcan ingot into sheet, plate, sections, forgings, castings and other forms. It is felt that there is a need today to establish more clearly the identity of the company with Aluminium Ltd., and to emphasize the advantages that the company offer customers of the considerable research and development resources within the whole enterprise, as well as of experience in the manufacture and application of aluminium in all parts of the world.

Other operating and trading companies in Aluminium Ltd. are currently changing their names for the same reasons and the common identification is the use of the name "Alcan"—symbolizing "Aluminium Ltd. of Canada", and stressing the Commonwealth nature of this enterprise. Associated with the name is the recently-introduced "Alcan" mark.

The origin of the old name "Northern Aluminium", has puzzled people who know that the company has no plants further north than Birmingham; in fact, this, the original name given to the parent company when first established in Canada at the beginning of this century, was used by what was then the British sales office, and has survived here until now. The products of Northern Aluminium Co. have become well known under the "Noral" mark, and Alcan Industries Ltd. propose to continue to use this trade name.

NEW DIRECTOR-GENERAL FOR A.D.A.

General Sir Geoffrey Bourne whose appointment as director-general of the Aluminium Development Association was announced in our August issue.

G.T.M.A. ENTERTAIN AMERICAN VISITORS

AT the beginning of October, a group of 35 directors of firms attached to the Detroit branch of the American Society of Tool and Manufacturing Engineers will be arriving in Great Britain and the Gauge and Tool Makers' Association will be acting as the host during their stay in this country.

The Association has arranged for the group to visit a number of automobile, aircraft, and general engineering firms in Great Britain and also S.I.M.C.A. at Poissy, near Paris.

On Wednesday, October 5, the Association is entertaining the American group to a luncheon at the Savoy Hotel, London, and on Friday, October 7, the group will be the guests of the Dollar Exports Council at a buffet luncheon in the City of London.

Prof. GEORGE EDSON DANFORTH

I.Prod.E. AWARDS

THE council of the Institution of Production Engineers has approved the following medal awards for the year 1958/9:—Mr. S. G. E. Nash of Bristol Aircraft Ltd., has been awarded a silver medal for his paper on "Metallic Materials and Process Development for Aircraft Applications," as the best paper presented to a section or region of the Institution by a member; Dr. W. L. Kent of the British Aluminium Co. Ltd., Warrington, has been awarded a silver medal for his paper on "Management of Men" as the best paper presented to a section or region of the Institution by a non-member and the J. D. Scaife medal for the best paper published in the Journal of the Institution other than those presented to sections or regions, has been awarded to Mr. C. J. Tanner of Solex (Gauges) Ltd., for his paper on "Air Gauging—History and Future Developments."

The awards will be presented at the annual dinner at the Dorchester Hotel, London, on November 2, 1960.

SCHOLARSHIP

FOLLOWING the recent announcement of the setting up of a scholarship scheme administered jointly by Constructors John Brown, Ltd., and the Institution of Chemical Engineers, a research scholarship has now been awarded to Mr. M. D. Taylor of the Department of Chemical Engineering, King's College, University of Durham, to the value of £450 per annum, for two years in the first instance. The purpose of the scholarship is to encourage research in chemical engineering and, in particular, in chemical plant design.

ARCHITECTURAL USES OF STAINLESS STEEL

LECTURES entitled "Recent Developments in the Architectural Uses of Stainless Steel in the U.S.A." were given by Prof. G. E. Danforth on September 5 and 6, 1960, at 66, Portland Place, W.1, supported by an exhibition of the uses of stainless steel in architecture brought from the U.S.A. The lecture was presented by the Stainless Steel Manufacturers' Association by courtesy of the Royal Institute of British Architects and was illustrated by two sound/colour films and approximately ninety slides. The lecture dealt with the case histories of five important buildings in the U.S.A. and one in Canada:—

White Castle General Offices Building, Columbus, Ohio.
The Union Carbide Building, New York.
Pottstown Hospital, Pottstown, Pennsylvania.
Gateway Centre No. 4, Pittsburgh, Pennsylvania.
The National Bank of Detroit, Detroit, Michigan.
130, Bloor Street, Toronto, Canada.

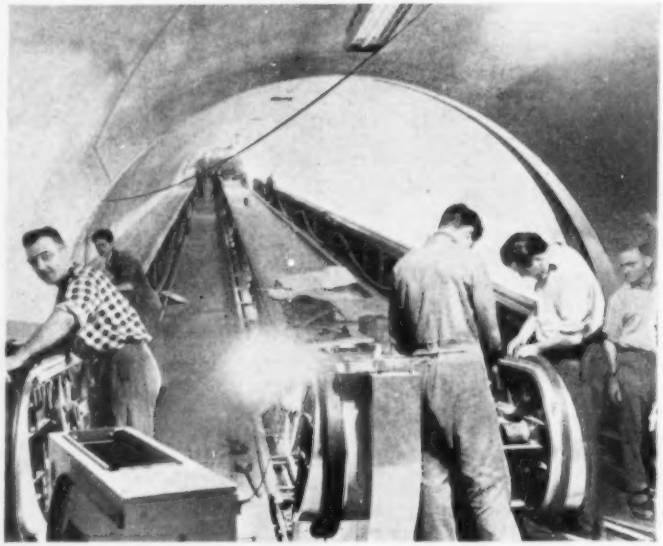
Reference was also made during the lecture to the use of stainless steel in the Empire State Building, New York and the Chrysler Building, New York. The exhibits included scale models of buildings, actual examples of curtain wall panels, window frames and other applications in stainless steel and a range of available forms giving some indications of the workability of the metal. Sections of the exhibition dealt with the fabrication of stainless steel and the use of different surface finishes.

Professor Danforth is director of the Department of Architecture at the Illinois Institute of Technology, Chicago, U.S.A., and is one of America's leading authorities on the uses of stainless steel in architecture and on the techniques of curtain walling.

Further lectures supported by the exhibition will be given in Milan, Paris, Dusseldorf, Stuttgart and Brussels. Professor Danforth will also lecture at Rome, Marseilles, Lyons, Strasbourg, Lille, Berlin, Hamburg and Munich before returning to the U.S.A. on October 15.

TRAV-O-LATOR AT THE BANK UNDERGROUND STATION

THE Trav-O-Lator referred to in the July issue of *Sheet Metal Industries*, which is shown nearing completion in the accompanying photograph, was officially opened on September 27. The apparatus connects the station with the booking hall at the Bank end and is capable of carrying 1,200 people in two minutes at a normal running speed of 180 ft. per min. Designed by the Otis Elevator Co. Ltd., part of the equipment was manufactured by James H. Randall and Son Ltd., Paddington Green, London.



SYMPOSIUM ON POWDER METALLURGY

THE next meeting of the Powder Metallurgy Joint Group of The Iron and Steel Institute and The Institute of Metals will be held at Church House, Great Smith Street, London, S.W.1, on Thursday and Friday December 15 and 16, 1960.

One day will be devoted to a Symposium on "The Practical Aspects of Pressing Metal Powders," papers contributed to which will be printed, in advance of the meeting, in "Powder Metallurgy," the half-yearly periodical of the Group. On the second day there will be discussions on papers which have been offered and accepted for printing in "Powder Metallurgy."

The Committee of the Joint Group wish to emphasize that it is not their intention that Group meetings shall be restricted to the discussion of invited papers on particular themes; it is hoped that the meetings may, in fact, be devoted to the discussion of scientific and technological papers which have been submitted for publication without invitation.

EFFLUENT AND WATER TREATMENT EXHIBITION

THE papers to be read at the above exhibition and convention to be held at the Seymour Hall, London, from October 18–21 total 13 and will include the following 10 in addition to the three papers referred to in our September issue—"Biological Treatment of Industrial Wastes," by J. W. Abson and K. H. Todhunter, "River Pollution Prevention in Scotland," by R. W. Covill, "Pumping," by T. Irvine Hudson, "The Application of Polarography to the Analysis of Sewage and Industrial Wastes," by J. Hetman, "Problems of Design in Effluent Treatment Plants." by J. W. Oakley, "Coastal Pollution," by J. A. Wakefield, "Disposal of Radioactive Effluent," by P. A. L. Northcott, "Water Softening for Industrial and Domestic Purposes," by W. M. T. Boby, "Application of Chlorine and Sulphur Dioxide in the Treatment of Trade Wastes," by P. E. Cockill and J. Malpas, and "Recent Advances in Boiler Feed Water Treatment," by G. L. Quayle.

COMPRESSED AIR AND HYDRAULICS EXHIBITION

EMPIRE Hall, Olympia, London, April 30–May 4, 1962, will once again be the background for the International Compressed Air and Hydraulics Exhibition and Fluid Power Conference.

NATIONAL CONFERENCE ON MANIPULATION OF METALS

THE Institution of Production Engineers is organizing a National Conference, to be held in Brighton from October 12–14, 1960, in order to focus attention on the recent significant technological developments in methods of manipulating metals which do not involve cutting.

An impressive programme of 16 papers is being drawn up, and will be presented under the following main headings: Extrusion techniques, Precision Forging, Form and Spline Rolling, Sheet Forming.

In addition to the Plenary sessions, which will take place in the Dome and Corn Exchange, the delegates will be welcomed by the Mayor of Brighton at a civic reception on the evening of October 12, and the conference will end with a presidential reception and dance on Friday evening, October 14, at the Hotel Metropole.

The conference fees are: Corporate members of the Institution, £7 7s.; Graduates and Students, £3 13s. 6d.; Non-members of the Institution, £10 10s.; Ladies £2 2s.

The conference will be opened by a plenary session at which the address will be given by Dr. D. F. Galloway, director of The Production Engineering Research Association.

Fuller details and application forms may be obtained from The Secretary, The Institution of Production Engineers, 10, Chesterfield Street, Mayfair, London, W.1.

MECHANICAL HANDLING EXHIBITION

THE next Mechanical Handling Exhibition—the world's largest display of all classes of industrial labour-saving and ancillary equipment—is to be held at Earls Court, London, from May 8 to 18, 1962. It will be the eighth in the series of this biennial exhibition which started in a modest way in 1948.

CONFERENCE ON OPTICAL INSTRUMENTS

A CONFERENCE on optical instruments and techniques is being arranged by the British National Committee for Physics, under the auspices of the International Commission for Optics. It will be held in London during the period July 10 to 14, 1961. Enquiries should be addressed to Mr. K. J. Habell, National Physical Laboratory, Teddington, Middlesex, England.

FIRST INTERNATIONAL INDUSTRIAL FINISHES EXHIBITION FOR 1961

THE growing importance of a new techniques and improved technologies in the field of industrial finishes with their almost universal relevance to the problems of international industry, makes it particularly appropriate that the First International Industrial Finishes Exhibition is now announced to be held at Earls Court, London, from May 8 to 11, 1961.

The exhibition will feature equipment, materials, plant and processes used in the industrial finishing field, and exhibits will incorporate metal pre-treatments, paints and their applications, electro-plating, galvanizing, metal colouring, anodizing, plastic covering, vitreous enamelling, shot-blasting, vacuum deposition, instrumentation and all the necessary ancillary equipment for the finishing of industrial products.

The Exhibition is being organized by the Exhibition Division of Scientific Surveys Ltd., 97, Old Brompton Road, S.W.7. (Tel.: KNIghtsbridge 9360) from whom all details can be obtained.

NORTHERN MACHINE TOOL EXHIBITION

AT the Northern Machine Tool Exhibition held by B. Elliott (Machinery) Ltd., at the City Hall, Deansgate, Manchester on September 19 to September 24, over 80 new machine tools were shown under power, every one built in Britain; these included milling, shaping, drilling, planing and grinding machines.

An open-sided planer known as the Invicta-Hydetsco was transported to Manchester in a special low-loader. This machine and controls weigh 16 tons.

Indian Order for Distington

DISTINGTON ENGINEERING CO. LTD., Workington, a branch of The United Steel Companies Ltd., in conjunction with their associates Concast A.G., Zurich, are to build a vertical continuous casting plant for billets on behalf of Canara Workshops Ltd., Mangalore, India.

The plant will be a single strand unit designed to cast from 2 in. square to 4 in. square billets but equipped to cast 3½ in. square billets initially. Provision is being made in the structure for the addition of a second strand at a later date. Main qualities to be cast will be silicon manganese steel.

Merger of Cambridge Instruments and Electronic Instruments

DR. P. DUNSHEATH, C.B.E., D.Sc., LL.D., chairman of the 79-year old Cambridge Instrument Co. Ltd., Cambridge House, Grosvenor Place, London, S.W.1, announced recently that his company has made an offer for the whole of the ordinary share capital of the 15-year old Electronic Instruments Ltd., Richmond, Surrey, on the basis of seven Cambridge 5s. shares for three £1 E.I.L. shares. At the current London Stock Exchange quotation for the Cambridge 5s. shares of 25s. 6d. this represented a total of £550,370 for the 185,000 E.I.L. issued ordinary shares, which the E.I.L. directors have recommended should be accepted by the shareholders. It is anticipated that this merger of two companies will create a more powerful organization to meet the rapidly changing conditions and requirements of the home and overseas markets.

It is intended that Electronic Instruments Ltd. will operate under its own name and that Mr. A. C. W. Norman will continue as chairman, Mr. P. Goudime, managing director, and Mr. D. A. Pitman as sales director, joined by three directors of Cambridge Instrument Co. Ltd. Subject to acceptance of the offer, Mr. Goudime will be invited to join the board of the Cambridge Instrument Co. Ltd.

Spark-Resistant Tools

OPTOSHIELD LTD., 146, Clerkenwell Road, London, E.C.1, have been appointed sole distributors in Great Britain, for Ampco Spark-Resistant Tools, a range of over 400 different types of which, in Ampco metal, beryllium-copper or Monel metal, are available in London. Ampco metal is used for tools such as hammers, rakes, saws, shovels, brushes and chains. When tools with cutting edges or gripping teeth are needed, Ampco beryllium-copper is used; its exceptional hardness and tensile strength makes it suitable for chisels, drills, knives, screw-drivers and pipe-wrenches. Monel metal tools are recommended for use in the presence of chemicals which attack high copper-base alloys, such as acetylene and other liquid gases used for cutting and welding.

Right.—Examples of spark-resistant tools

GAUGE AND TOOL MAKERS FORM EDUCATIONAL TRUST

THE GAUGE AND TOOL MAKERS' ASSOCIATION, is establishing a body to be known as The Gauge and Tool Makers' Educational Trust, the objects of which will be broadly:—

(*a*) To provide funds for grants to be awarded for the furtherance of technical education in Great Britain and elsewhere to apprentices, students, and other young members of the gauge and tool industry.

(*b*) To promote the knowledge of the products covered by the gauge and tool industry, and for that purpose to make arrangements for the publication, issue, and circulation of such papers, periodicals, books, circulars, and other literary undertakings, as may best advance and promote the study, general knowledge of, or research in, any branch of the gauge and tool industry.

(*c*) To arrange exhibitions and provide demonstrations which advance and promote the study, general knowledge of, or research in, any branch of the gauge and tool industry.

(*d*) To establish and support or aid in the establishment and support of any educational charitable association or institution, and to subscribe money for any educational charitable purpose in any way connected with any of the foregoing purposes.

A company to be known as The Gauge and Tool Makers' Trustee Co. Ltd. is being formed to act as the trustee of the trust, and subscribers to its articles of association have been appointed. These subscribers will in turn appoint the directors of the trust, who will act in close co-operation with The Gauge and Tool Makers' Association as the founder.

The funds of the trust have opened with a gift of £1,000 from Mr. Charles Grundy, who retired a few years ago from the managing directorship of a member-firm, and a substantial sum contributed by the association as founder.

Starrett Re-enter U.K. Market

THE L. S. Starrett Co. Ltd., a subsidiary of the American concern at Atholl, Massachusetts, have opened a modern factory at Jedburgh, Roxburghshire, covering an area of over 75,000 square feet, and production of Starrett bandsaw blades has already commenced; one machine alone is capable of producing 62,000 feet of bandsaw blades each week. Hacksaw blades will be the next product to come from the Scottish factory and it will be a year or so before full production of measuring tools and other precision instruments is attained.

Metal Industries and Lancashire Dynamo Merger

METAL INDUSTRIES LTD. have acquired under Section 209 of the Companies Act, 1948, the outstanding balances of Ordinary and 5½ per cent Cumulative Preference Stock in Lancashire Dynamo Holdings Ltd. for which acceptances were not received from the holders. Any holder who has not received the cash and/or the shares to which he is entitled may receive the same on applying to the company, completing forms of acceptance and transfer and surrendering his Lancashire Dynamo Stock Certificate which is now useless. On completion of this transaction and following the recent rights issue, the issued capital of Metal Industries Ltd. now stands as follows:—

5 per cent Cumulative Preference Stock ..	£1,212,000
3¾ per cent Cumulative Preference Stock ..	£1,560,000
Ordinary Stock (ranking for final dividend for the year to March 31, 1960	£4,140,338
New Ordinary Stock (not so ranking) ..	£3,334,785
	£10,247,125

APPOINTMENTS and STAFF CHANGES

Sir Joseph Latham, C.B.E., has been elected a director of the **Associated Electrical Industries, Ltd.,** 33, Grosvenor Place, S.W.1, and Mr. C. R. Wheeler, C.B.E., has been appointed an additional vice-chairman and will take up executive duties in 1962.

The Rt. Hon. The Viscount Head of Throope, P.C., C.B.E., M.C., has resigned from the board as a result of his appointment as the first High Commissioner in the Federation of Nigeria. Viscount Head became a director of A.E.I. at the end of December, 1957.

* * *

Mr. T. J. McArthur has joined the board of **Blake Vitreous Enamelling Ltd.,** Clayton-le-Moors, and will act in the capacity of general manager. Mr. McArthur has had many years experience in management within the vitreous-enamelling industry and until recently was a director and general works manager of Stewart and Gray Ltd. In recent years he has been concerned with pioneering the use of vitreous enamelled steel in building construction. Blake Vitreous Enamelling Ltd. operate one of the largest and most modern vitreous-enamelling plants in the United Kingdom and current expansion will expand present capacity and enable the company to develop new products.

* * *

The following appointments have been made in the sales organization of **The Brightside Foundry and Engineering Co. Ltd.,** of Eccles-field, Sheffield:—

Mr. G. E. Robinson, general sales manager; Mr. G. H. Lewis, sales manager, foundry Division; and Mr. T. Hessey, technical sales manager.

* * *

Mr. A. R. Jackson has been appointed to the board of the **Consolidated Pneumatic Tool Co. Ltd.,** of 232, Dawes Road, London, S.W.6. Mr. Jackson is general manager of the company's Australian branch and will continue in charge of operations in that country. Joining the company in Australia in 1927, Mr. Jackson was appointed general manager of the Australian branch in 1952.

Dawe Instruments Ltd. of 99/101, Uxbridge Road, Ealing, London, W.5, have become members of the Simms Group of companies. Mr. F. W. Dawe continues as managing director with Mr. G. E. Liardet as chairman of the board of directors. Other members of the board are J. Ayres, M. A. Hassid and K. G. Smith.

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E.M.I. Electronics Ltd. announce that A. E. Oates has been appointed press and publicity manager.

Mr. Oates was formerly publicity officer of The Distillers Plastics Group of Companies.

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Guest Keen and Nettlefolds (Midlands) Ltd., announce the appointment of Mr. H. V. Bouldstridge (sales organizer, Guest Keen and Nettlefolds (Midlands) Ltd., Screw Division) as a director of the company.

* * *

Mr. C. F. Pagnamenta, O.B.E., F.C.A., secretary of **Guest Keen Iron and Steel Co., Ltd.,** has been elected a director. He joined the company in October, 1957, as chief accountant and became secretary in August, 1959.

* * *

Hadfields, Ltd., Sheffield, announce the appointment of two further local directors, Mr. Denis R. Ward, assistant secretary of the company and secretary of several of the subsidiary companies in the group, and Mr. Arthur W. Gurney, A.C.W.A., who joined Hadfields in 1951 and is chief cost accountant of the company.

* * *

Mr. J. Alcock has been appointed to the board of **Midgley and Sutcliffe, Ltd.,** the 600 Group company which manufactures the "Richmond" range of radial drills and milling machines at Hunslet, Leeds.

Works manager with Midgley and Sutcliffe since 1956, Mr. Alcock came to the company from Fairbairn, Lawson Combe Barbour, Ltd., where he was general works manager. From 1940-45 he managed a Ministry of Supply factory in Dundee. He served his apprenticeship with Craven Bros., Ltd., of Manchester.

* * *

Richard Thomas and Baldwins (Sales) Ltd., 47, Park Street, London, W.1, have appointed the following directors: Mr. P. M. J. Boulasse, Mr. S. C. Burgess, Mr. G. Durward, Mr. L. G. Stock.

* * *

Tube Investments Ltd. announces that Mr. W. W. Hackett, Senr., C.B.E., on retiring from the chairmanship of **Accles and Pollock Ltd.** after 61 years' service with that company, which he helped to found, has accepted an invitation to become its first president.

Mr. Hackett was also a founder member of Tube Investments Ltd., and served for many years as a director.

* * *

Wolf Electric Tools Ltd. announce the appointment of Mr. Hans Mäder as Sales Supervisor for Switzerland—one of the oldest established markets for their industrial and domestic range of power tools. Mr. Mäder's address is Bürenstr. 33, Lengnau. b. Biel, Switzerland.

Mr. HANS MÄDER

The Workington Iron and Steel Co. branch of The United Steel Companies Ltd. announce a number of new appointments: Mr. G. Pott, at present works engineer, is to become chief engineer. Mr. W. Hunter, blastfurnace manager, is appointed ironworks superintendent, with responsibility for ore preparation and blastfurnaces. Mr. F. Greenhalgh succeeds Mr. Hunter as blastfurnace manager. Mr. J. D. Young, Bessemer manager, becomes assistant steelworks superintendent, and is succeeded as Bessemer manager by Mr. G. Forster, at present Bessemer shift manager.

ANGLO-AMERICAN TRADE RELATIONS

ADDRESSING a press conference held at the headquarters of the Federation of British Industries, Lord Rootes spoke of the success of the British Exhibition held in New York for which the attendance figures have been estimated to be far in excess of anything of its kind so far experienced; over 30,000 buyers registered their names and more than 10,000 people made enquiries at the joint stand of the Dollar Exports Council and the Federation of British Industries; in addition, more than 100 genuine enquiries for factory development in this country were received. The success more than compensated for the sceptical lack of enthusiasm that was met from sections of industry when the plans for this exhibition were made initially. Lord Rootes intimated, however, that while the success of the exhibition indicated that we could improve our export trade with the dollar areas, with the liberalization of the dollar trade being brought about by the British Government, it also meant that unless a more determined effort is made to export to the dollar countries and to the world as a whole, our balance of trade may grow gradually worse. Although the exports of the U.K. to the U.S.A. increased by 7.4 per cent for the month, imports to this country from America increased by no less than 95.6 per cent.

Lord Rootes stressed that failure to accept the seriousness of the intense competition from the continent and the U.S.A. is bound to bring about a disastrous situation ultimately.

Darlington Chemicals Subsidiary Changes Name

MR. D. J. GRANT, managing director of Darlington Chemicals Ltd., announces that the name of one of its principal subsidiary companies, the British Refrasil Co. Ltd., Stillington, Co. Durham, has been changed to Darchem Engineering Ltd. Ownership and board of the company remain unaltered and all existing activities will continue.

The division of the company supplying Refrasil insulation blankets will be known as the "British Refrasil Division." The other main interests of Darchem Engineering Ltd., are, stainless-steel foil internal insulation for reactors and allied equipment, Rostenit stainless-steel tank linings, general light-gauge stainless-steel fabrication and specialized welding processes.

£2 MILLION EXTENSION TO ROLLING MILLS

A £2 MILLION civil engineering and building contract for extensions to the Trostre and Velindre works in South Wales has been awarded to Robert M. Douglas (Contractors) Ltd. This contract, involving extensions to the rolling mills that will increase the capacity of the plant, forms part of a £20 million development scheme in the tinplate division of the Steel Company of Wales Ltd. Three further contracts, with a total value of £1 million, have been awarded for the erection of warehouse extensions for Typhoo Tea Ltd. in Birmingham, the construction of factory extensions, roads and railway sidings for Tubes Ltd., Desford, and work on the new continuous tube production plant and the stainless tube mill for the Talbot Stead Tube Co. Ltd.

Change of Name

ON August 2, 1960, C. C. Wakefield and Co. Ltd. changed their title to Castrol Ltd. This decision was taken because since the war, their business has grown considerably and the post-war generation attach greater significance to the name of Castrol than to the family name of the producers.

REPORT OF PATENT OFFICE FOR 1959

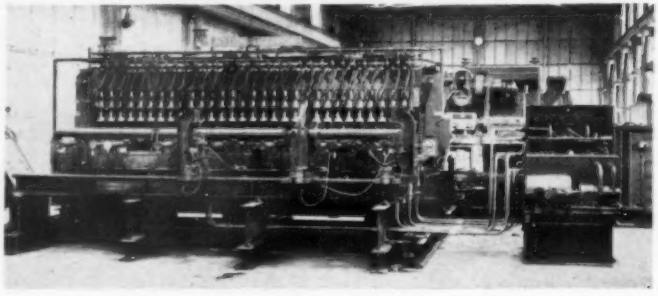
THE Comptroller-General's annual report on the work of the Patent Office in 1959, published recently, refers to the continued increase in applications for patents and trade marks and in applications from other countries, including the Soviet Union. The continued rise in applications and the difficulty in recruiting staff have led to a substantial arrear of unexamined patent specifications, although this has not increased in proportion to the number of applications. The report refers to those fields in which new development has been most marked.

Applications for trade marks continue to increase, partly it is thought because of the increased advertising of consumer goods and a tendency to seek a trade mark for each new line rather than a mark covering a whole range of goods. Mention is made of the committee which is considering the law relating to industrial designs and of international discussions in the field of industrial property.

Copies of the Report are available from H.M. Stationery Office, Kingsway, London, W.C.2 and branches, price 1s. 6d. (by post 1s. 8d.).

WIRE-MESH WELDING MACHINE

THE photograph illustrates a 15-ft. wide fully automatic wire-mesh welding machine designed for the production of road reinforcement mesh. The machine, which is completely automatic, is designed to feed both longitudinal and cross wires from coil through straightening equipment and is fitted with a hydraulically powered feed table giving a wide range of adjustment for variation of the mesh sizes. A unit type head construction is employed to enable the pitch between the longitudinal wires to be varied at will and the machine incorporates a slitting unit which is used for dividing 15 ft. wide mats into smaller sections as required. Output speeds obtainable are approximately 50 wires per minute on a 3-in. mesh and while the illustration shows the machine fitted with a single wire feeding and straightening unit, it is designed to accept two wires of this type to give the maximum output. The capacity of the machine is from 10 gauge to 4/0 gauge wires with pitches variable from 2 in. upwards; other models are available covering smaller sizes. The manufacturers are the British Federal Welder and Machine Co. Ltd., Castle Mill Works, Dudley, Worcs



MEETINGS OF THE MONTH

October 4

Institute of Sheet Metal Engineering (South West Branch). Forum on "Economic Considerations in the Use of Metal Sheet," at the Small Lecture Theatre, Engineering Laboratories, University of Bristol. 7 p.m.

Institution of Plant Engineers (Peterborough Branch). "Modern Trends in Machine Tools" by a representative of Newall Engineering Co. Ltd. at the White Lion Hotel, Church Street, Peterborough. 7.30 p.m.

October 5

Institution of Plant Engineers (Leicester Branch). "Metal Stitching" by N. Tinwell, Chief Engineer, Metalock (Britain) Ltd. at the Saracen's Head Hotel, Leicester. 7.30 p.m.

Institute of Sheet Metal Engineering (Midland Branch). Visit to Joseph Lucas Ltd., followed by supper and social evening at the White Horse, Congreve Street, Birmingham.

Institution of Production Engineers (North Midlands Region). "Investment Casting for the Engineer" by I. L. Gwymm, L.I.M., A.C.T.C. at the Reform Club, Victoria Street, Nottingham. 7 p.m.

October 10

Institution of Plant Engineers (London Branch). "Plant Engineering on the Continent," at the Royal Society of Arts, John Adam Street, Adelphi, Strand, W.C.2. 7 p.m.

Institution of Chemical Engineers (London Branch). "Symposium on Surface Effects and Liquid Behaviour" at the Royal Institution, Albemarle Street, W.1. 7.30 p.m.

October 12

Society of Instrument Technology (Manchester Section). "Data and Handling Processing" by E. K. Robertson, M.A. at the College of Science Technology, Sackville Street, Manchester. 6.45 p.m.

Institution of Plant Engineers (Western Branch). "Steam for Process" by L. G. Northcroft, O.B.E., B.Sc. (Eng.), M.I.Mech.E., M.I.H.V.E., F.I.Plant E. Main lecture theatre, University of Bristol. 7.15 p.m.

October 13

Institution of Plant Engineers (North-East Branch). "Materials Handling" by E. R. C. Farmer, Winthrop Laboratories Ltd. at Roadway House, Newcastle-upon-Tyne, 1. 7 p.m.

October 17

Institution of Production Engineers (East & West Ridings Region). "Production Welding Techniques" by a representative of Robert Jenkins and Co. Ltd. at Wortley Road, Rotherham. 6.30 p.m.

October 19

Institution of Production Engineers (Midland Region). "Precision Investment Casting Techniques" by W. N. Jones at the James Watt Memorial Institute, Great Charles Street, Birmingham. 7 p.m.

Institution of Plant Engineers (Kent Branch). "Refractory Brickwork for Boilers and Furnaces" by N. W. Hinchcliffe of Morgan Refractories Ltd. at the King's Head Hotel, High Street, Rochester. 7 p.m.

October 20

Institute of Sheet Metal Engineering (North-West Branch). "Automatic Presswork on Multi-Slide Machines" by J. Hayes (Rockwell Machine Tool Co Ltd.) at the Engineers' Club, Albert Square, Manchester. 7 p.m.

Institution of Mining and Metallurgy. General meeting and discussion. "Mining of Cupreous Stockwork Ores at Rio Tinto" by R. N. Pryor, "Extraction of Copper and Silver by the Segregation Process in Peru" by F. Pollandt. The Geological Society, Burlington House, Piccadilly, London, W.1. 5 p.m.

October 26

Society of Instrument Technology (South Wales Section). "The Automatic Control of Rolling Mills" by W. N. Jenkins, B.Sc. (Eng.), A.M.I.E.E. at the Lecture Theatre of the Steel Company of Wales Ltd., Port Talbot. 5.30 p.m.

Institute of Sheet Metal Engineering (Wolverhampton Section). "Finish and Conventional Blanking Techniques" by F. Howard (P.E.R.A.) at the Wolverhampton and Staffordshire College of Technology. 6.45 p.m.

October 28

Society of Instrument Technology (Scottish Section). "Instrumentation of a Steel Strip Mill" by H. Gill at the Building Centre, Sauchiehall Street, Glasgow. 7.15 p.m.

PRODUCTION OF HIGH-PURITY METALS ON COMMERCIAL SCALE

JOHNSON, MATTHEY and CO. LTD., announce that they are now producing very pure arsenic, antimony, tellurium and bismuth on a commercial scale. By means of newly developed techniques, arsenic is being produced with an impurity level of the order of 1 p.p.m., detected by use of present known and accepted spectrographic methods. The element is in the form of crystalline lumps and is packed in vacuum-sealed glass tubes. Antimony, with a maximum metallic impurity content of 5 p.p.m., and bismuth, with a maximum level of metallic impurities of 10 p.p.m., are being produced in ingot form. Zone-refined tellurium, with a metallic impurity content of the order of 1 p.p.m., is also available in bulk, in the forms of ingot or grain. Of increasing importance to the semiconductor industry, these four high purity metals find growing application in the form of inter-metallic compounds. For example, gallium arsenide is used in the production of special diodes and transistors, indium antimonide and indium arsenide are used for magneto-sensitive devices and bismuth telluride is used in Peltier cooling units.

INDUSTRIAL COLOUR TV.

A COLOUR television mobile unit can now bring true-to-life colour pictures on a 7-ft. by 4-ft. screen to offices, factories, conferences and exhibitions anywhere in Great Britain. This unit, equipped and operated by E.M.I. Electronics Ltd., Hayes, Middlesex, carries two of E.M.I.'s new colour TV cameras, which incorporate a novel optical system several times more efficient than relay lens systems. These cameras are very compact and give accurate colour renderings, even under difficult lighting conditions, so are ideal for industrial use. Facilities are also provided on the unit for colour telecine and colour microscopy.

Publications for Industry

Dowding and Doll Ltd., 346, Kensington High Street, London, W.14, have issued a pamphlet describing the range of "RG" 5-ton, 10-ton and 15-ton high-speed hydraulic presses which have recently been introduced by them.

* * *

"Platinum Metals Review" issued by Johnson Matthey and Co. Ltd., Hatton Garden, London, E.C.1, contains, amongst others, an article on Corrosion Control by Anodic Protection and eight pages of abstracts on current literature on the platinum metals and their alloys.

* * *

"Resistance Welding at Work," Vol. 5, No. 7, issued by Sciaky Bros., 67th Street, Chicago 38, Illinois, contains an article on the method of fusion welding, using a stream of electrons in a high-vacuum chamber, which has been under development by Sciaky for a number of years and which results in welds of ultra-high purity for refractory and reactive metals.

* * *

A survey of the main causes of noise in factories and available methods of reducing it has been published by H.M.S.O. for the Department of Scientific and Industrial Research, Charles House, 5-11, Regent Street, London, S.W.1., as the sixth in the series Factories Building Studies —"Noise in Factories." The booklet can be obtained from any bookseller, price 3s. 6d. or by post from H.M.S.O.—3s. 10d.

* * *

The Aluminium Development Association, 33, Grosvenor Street, London, W.1, have published a new edition of Information Bulletin No. 18, "Working Bulletin in Shipyards," price 2s., 60 pp., (illustrated). The general plan of the book is substantially as before, the first section dealing with working practice such as sawing, milling, arc cutting, bending and forming and sheet-metal work; the second section deals with joining methods, prominence being given to the inert-gas shielded-arc methods developed since the first edition was published. Other sections deal with practice when aluminium is in contact with other materials and with painting and protection.

F. J. Edwards Ltd., 359-361, Euston Road, London, N.W.1, have issued a leaflet No. Whit/160-2 giving details of the range of angle iron machines and hand punches produced by them.

* * *

"SS News," June, 1960, published by Solus-Schall Ltd., County Building, Honeypot Lane, Stanmore, Middlesex, which is devoted to non-destructive testing, contains several articles of considerable interest on ultrasonic equipment used for flaw detection in plates and tubes.

* * *

"Dawe Digest" recently issued by Dawe Instruments Ltd., 99-101, Uxbridge Road, London, W.5, contains an article describing how ultrasonic gauging helps the aircraft industry.

* * *

The annual report for 1959 of the Tin Research Institute, Fraser Road, Perivale, Greenford, Middlesex, mentions several lines of investigation in metallurgy, tinplate, and electrodeposition; several new studies of the properties of tinplate are mentioned as well as a new method of assessing porosity of tin coatings by pounds of flow of current. It has been found that bright deposits of tin can be made by electrodeposition using wood tar additions in the plating vat.

* * *

A 12-page brochure issued by the Lead Industries Association, 292 Madison Avenue, New York 17, makes it possible to estimate in a matter of minutes, the costs incurred by industrial trucks. Charts show accurately the costs of depreciation, operation and maintenance for both petrol-driven and battery-operated trucks indicating that while the initial costs of electrical trucks are higher, the total overall costs are 40 to 50 per cent lower than petrol-driven trucks.

* * *

"Lead," Vol. 24, No. 1, also issued by the Lead Industries Association introduces Devcon L, a putty-like material produced by Devcon Corp. of Danvers, Mass. consisting of 94 per cent lead powder and 6 per cent special epoxy resins, which can be easily formed into any shape before curing, but after the addition of a catalyst or hardening agent, becomes a hard, rigid, tough, strong mass; no heat, pressure or flame is required. By using Devcon Flex in place of the hardening agent a flexible material is produced similar to an automobile tyre. The use of lead is also described in the lining of eight pools decorating the new Time and Life Building in New York.

"Murex Review," published by Murex Ltd., Rainham, Essex, contains a 12-page article on the effect of molten metals on stressed solid metals and a 20-page article on vacuum sintering.

* * *

"Wiggin Nickel Alloys," No. 56, includes an article on eddy-current testing, one aspect of the company's comprehensive and exacting system of quality control.

Contrasting uses of nickel and nickel alloys are featured—from anodes for electroplating, one of the oldest and best known applications, to the use of some of the "Nimonic" series of heat-resisting materials in the "Zenith" experimental gas-cooled nuclear reactor.

Other articles include the use of "Nimonic 80A" in valves for the "Vanwall" racing car and two seagoing applications of "Monel" alloy in trawlers and runabout pleasure craft.

This publication is free on request from the Publicity Department, Henry Wiggin and Co. Ltd., Thames House, Millbank, London, S.W.1.

* * *

Abstracts indicating the scope and main findings of papers presented at the 46th Annual Convention of American Electroplaters' Society form an interesting feature of the April issue of "The Nickel Bulletin." These and the other items comprising the section concerned with nickel plating cover work on the properties of plating solutions and electrodeposits, research on corrosion testing, and, in particular, investigations carried out with the aim of developing methods of improving the corrosion-resistance of electrodeposited coatings.

In the nickel section of the issue reference is made, *inter alia*, to items on analysis. Worthy of note in the section on non-ferrous alloys is an abstract of a paper reporting work on nickel-containing gunmetals, while the items on heat- and corrosion-resisting alloys and steels range in subject matter from the mechanical properties of high-temperature alloys to fuel-oil-ash corrosion, use of austenitic steels in steam-power plant, potentiostat studies, and the behaviour of various materials in the presence of specific corrosive media.

In addition to the usual sections concerned with cast iron and constructional steels, the April issue contains the quarterly review of recent patent literature. The publication can be obtained from The Mond Nickel Co. Ltd., Thames House, Millbank, London, S.W.1.

New Plant and Equipment

Improved Welding Process

ROCKWELD LTD. of Commerce Way, Croydon, Surrey, announce that they propose to introduce into this country shortly, the "Comatic" welding process, which is claimed to overcome the difficulties of fast vertical welding of relatively thin plates in mild and low-alloy steels, and will in fact weld plates down to ¼-in. in thickness. The principle of operation is that the wire and parent plate are melted by an arc, the weld being protected by CO_2 gas. The molten weld metal is contained by water-cooled copper shoes, located on opposite faces of the plate being welded and traversing upwards as welding proceeds.

The machine consists of a vertical frame with two tracks carrying the welding head carriage which is equipped with a wire feed roll drive, a wire drum, a vertical traverse drive mechanism, an adjustable wire guide oscillation device and fixtures for carrying the copper shoes. Controls and meters are incorporated in a cabinet attached to the top of the carriage. The column, which is fitted with a lifting lug so that the machine can be craned to an appropriate position on the workpiece, clamps directly on to the workpiece and the structure is as light as possible consistent with rigidity.

In operation, the CO_2 arc gives the necessary side wall penetration with a small gap. When thin plates are being welded the wire is fed in centrally between the plates; for heavier plates, the wire is made to oscillate across the thickness of the material. High operational speeds are possible; for example, with ⅜-in. thick plate, a speed of 15 ft. per hr. is possible; high-quality weld metal and perfect radiographs are claimed to be obtained and impact properties are good.

The power requirement is a standard, drooping characteristic, welding generator or transformer/rectifier equipment of similar characteristic fitted with current control only, arc voltage control being fitted to the welding head. The welding generator or transformer/rectifier should be rated at 750 amp. for continuous duty.

Power-operated Collet Chuck

F. BURNERD AND CO. LTD., 5, Balfour Place, Park Lane, London, W.1, have recently brought on to the market a new high-speed, power-operated "multisize" collet chuck, Fig. 1, which can be operated by either hydraulics or pneumatics. The chuck rotates inside the stationary double-acting cylinder, which is supported on a needle roller bearing and gives speeds up to 3,000 r.p.m. This self-contained design allows the chuck to be mounted on any machine spindle without special adaptors or supports for the non-rotating components and it is therefore universal in its applications. It is basically designed for the range of "Multisize" collets in the various standardized ranges up to 2½ in. dia. bar capacity, which, the manufacturers claim, combined with dimensional flexibility and sturdy construction of even ordinary jaw chucks achieves standards of accuracy that are unobtainable with orthodox spring collets. Variation in sizes of components within the rated capacity of the collet does not affect the parallel grip. Blades grip the workpiece along their entire length with a force many times more powerful than ordinary collets without distorting or marking even the most fragile components. Six alternative ranges are available, to meet the requirements of a wide variety of machine tools.

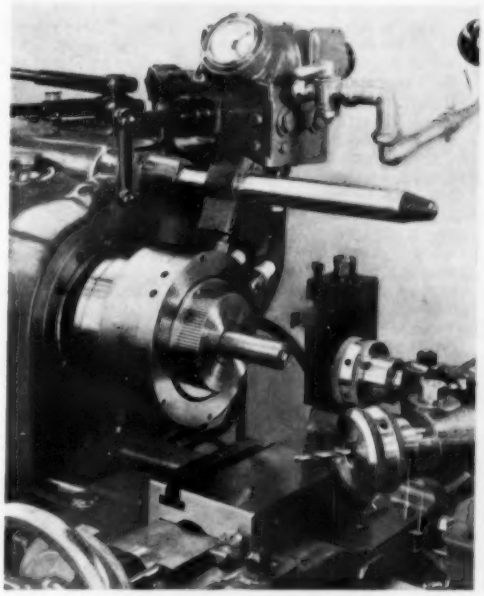


Fig. 1.—Power-operated collet chuck

Pocket Magnifier with Graticule

FIG. 2 shows a pocket magnifier with a graticule to ensure accurate readings of ± 0.002 in., which is being produced by Graticules Ltd., Bath House, 57/60, Holborn Viaduct, London, E.C.1. The magnifier folds into a neat square measuring 2½ in. by 1 $\frac{1}{16}$ in. by $\frac{7}{16}$ in.; the frame is aluminium cut away to give a field of vision of 1 in. and the graticule, which is bonded to glass by a process evolved by Graticules Ltd., is resistant to heat, chemical attack and abrasion and can be replaced in the event of breakage.

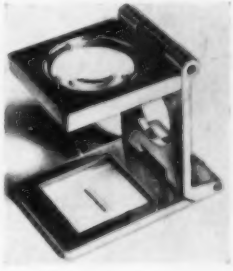


Fig. 2.—Pocket magnifier

High-Speed Hydraulic Presses

FIGS. 3 and 4 show a range of high-speed hydraulic presses, known as R-G, designed and built for Dowding and Doll Ltd. by Rhodes, Gill and Co. Ltd. There are three models—with 5, 10 and 15 ton pressure capacity. They are of streamlined design and entirely self-contained. The hydraulic reservoir, pump, motor, and all pipe work and control rods are fully enclosed within a fabricated steel frame. The presses have been developed to simplify and speed-up such operations as blanking and piercing, forming and bending, broaching, clipping, marking and assembly.

On all three models, operating pressure and slow ram advance for setting are controlled by a regulator fitted close to the pressure gauge for which an isolating valve is provided. Both the ram nose and the table are designed to accept most existing tooling. Perspex guards provide a clear view of the work while affording complete protection to the operator.

The 5-ton model can be supplied either as a bench press or with a pedestal for floor mounting. Operation is by means of a hand-rail which extends across the front of the press—an arrangement which permits working with either hand. The pedestal model can also be supplied for foot operation.

An accumulator system provides rapid ram approach with instantaneous speed reduction and the application of full operating pressure immediately the load is applied. The double-acting cylinder and ram provide positive power ram return. The ram is prevented from turning by a spring-loaded plunger housed within the frame. There is no obstruction of the table area and the stroke is readily adjustable.

Pressure can be maintained for normal periods and simple special equipment is available to extend the duration of pressing.

The speed of the ram on the approach, pressing and power return strokes is 1,000, 35 and 650 in. per min. respectively.

Both the 10-ton and the 15-ton models operate on the jack-ram prefill system. A guide is fitted to check rotation of the ram and full use of the table area is permitted without fouling the pillars of the die sets. A device can be fitted to limit the downward stroke which is readily adjustable by means of a knurled wheel projecting from the side of the press and permits accurate inching of the ram.

T-slotted tables are available for either model and a 4- or 8-station automatic rotary indexing table can also be incorporated. Extra high speed models are available.

Speed of the ram on the standard 10-ton model is 390, 35 and 186 in. a min. on the approach, pressing and power return strokes respectively. Speeds for the 15-ton model are 390, 21, and 140 in. per min.

The R-G range of presses is available from Dowding and Doll Ltd., 346, Kensington High Street, London, W.14.

(*Continued in page* 784)

Fig. 3.—*5-ton hydraulic press*

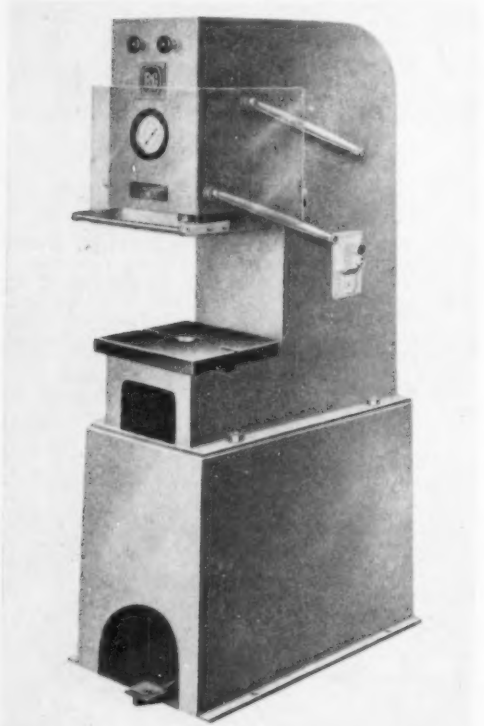
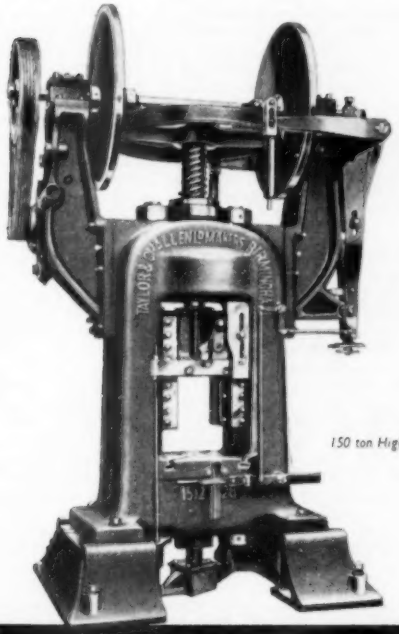
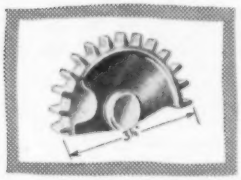
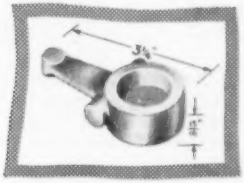


Fig. 4.—*15-ton hydraulic press*



150 ton High Speed Screw Press





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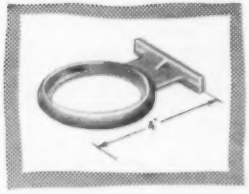

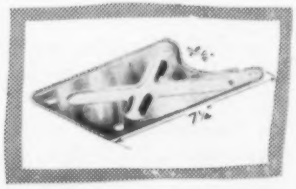

TAYLOR & CHALLEN LTD BIRMINGHAM 19

High Speed Cutting Nozzles

BRITISH OXYGEN GASES, LTD., Spencer House, St. James's, London, S.W.1, have developed a range of oxy-acetylene nozzles which are claimed to give faster machine cutting speeds than any existing models.

These new high-speed nozzles have been developed for machine cutting applications and are an addition to the "Saffire" range of equipment. They can cut 7-in. thick plate at 45 ft. per hour and 1-in. plate at 100 ft. per hour. They are available in four sizes: 45, 50, 60 and 73. The size numbers indicate the diameter of the throat passages in thousandths of an inch.

The new nozzles are claimed to lower the production costs of machine cutting and reduce the time spent on finishing and machine work. They are of one-piece construction and, apart from the conical seating surface, are chromium plated.

The cutting orifices, which are machined to exacting limitations, are of convergent-divergent form. This allows the cutting oxygen supply to expand to atmospheric pressure within the nozzle. The cutting oxygen leaves the nozzle at high speed in a parallel stream, resulting in an exceptionally high linear cutting speed.

Ultra High Strength Steels

A SERIES of ultra high strength steels for use at high temperatures has been developed by Samuel Fox and Co. Ltd., a subsidiary of The United Steel Companies Ltd.

The steels have been designed to give tensile strengths of between 100 and 140 tons per sq. in. after tempering at up to 600°C. In addition to permitting higher operating temperatures to be considered in design compared with steels which are currently being specified for these strength levels, the high tempering temperature will yield maximum stress relief and, therefore, greater dimensional stability.

There are at present three steels in the new series, of which the first is a commercial alloy already in production. This steel is well-known to give 100-tons tensile strength in the air-hardened and tempered condition. Formerly described as Fox 769, it has now been renamed HST 100.

The two entirely new steels in the series have been obtained by small compositional changes in the basic HST 100 analysis, but there is no increase in the carbon content while use has been made of a combination of solution hardening and improved tempering resistance. The steels are known as HST 120 and HST 140, and have tensile strengths of 120 and 140 tons per sq. in. respectively, at room temperature. It has been possible to reduce the carbon content of HST 120 to 0.30 per cent. Both these steels can be hardened in either air or in oil, depending on mass, and all three in the series have silicon contents below 0.40 per cent.

The HST steels can be produced in the form of billets, blooms and slabs for forging and re-rolling, and in bars for forging or machining. Bars can be supplied either in the annealed or fully hardened and tempered conditions. Experiments are taking place to produce sheets down to 0.064 in. thick in all three qualities, but these are not yet generally available.

Applications for the HST steels are expected to be found in the aircraft and rocket industries, although HST 140 could probably be used to advantage as a hot die steel.

Welding Turntables

COURTBURN POSITIONERS LTD. of Kempston Hardwick, Bedford, have produced a range of variable-speed welding turntables of 10 cwt., 1 ton and 3 ton capacity suitable for the rotation of workpieces during continuous welding operations where tilting of the components is not desired; the tables are 24 in., 36 in. and 54 in. in diameter respectively and the motors are totally enclosed, giving complete protection and safe operation. Two types of manually operated positioners are also available of 5 cwt. and 10 cwt. capacity which enable welds to be presented in all downhand weld positions; the turntable diameters are 24 in. and 30 in. respectively and rotate freely by hand in Timken taper roller bearings mounted in the crosshead and are secured every 30 deg. by a spring-loaded plunger; tilting of the turntables is effected through 135 deg. by a handwheel operating a worm and segment gear.

Spray Coating

THE PFAUDLER CO., a division of Pfaudler Permutit Inc., Rochester, New York, have introduced on a commercial basis, a sprayable coating of Penton in water-suspension, Pfaudlon 301, which can be applied to desired thickness (20 to 40 mils) with as few as two applications, while four or more are commonly required when alternate methods are used.

Penton is a chlorinated polyether polymer developed by Hercules Powder Co., having almost universal resistance to corrosion at temperatures to 250° to 275° F. and claimed to have excellent resistance also to abrasion and impact damage. Pfaudlon 301 is applied in approximately the same manner as are organic suspensions but Pfaudler consider that the water-spraying technique is superior because elaborate safety measures are not needed to guard against toxicity and inflammability. Fig. 5 shows Pfaudlon being wet-sprayed on cold metal.

Three firms have been licensed to use the process—American Durafilm Co. in Boston, Mercer Rubber Co. in New York and Electrochemical Engineering and Manufacturing Co. of Emmaus, Pennsylvania; it is expected that more firms will be licensed in the future.

(*Continued in page* 786)

Fig. 5.—Penton wet spray technique

Protection for Aluminium

. . . on unfinished or painted products

with the

BONDERITE 700

SERIES

and Pylumin

also new

Aluma Etch

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A scale free, controlled alkaline etchant for uniformly etching aluminium surfaces.

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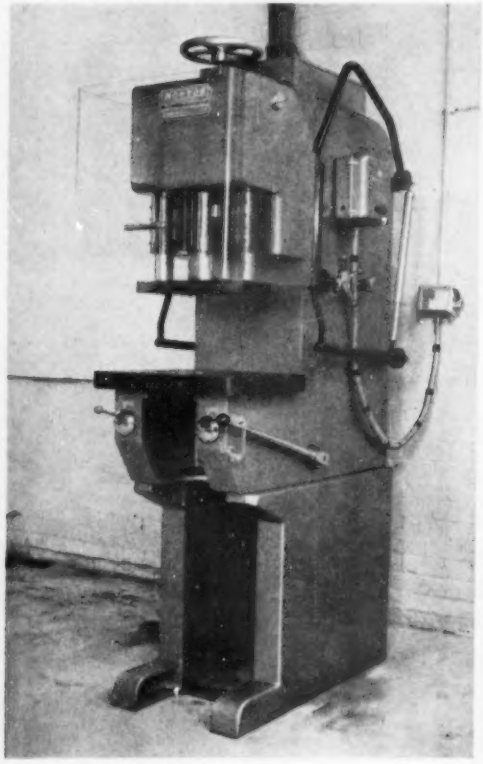
Automatic High-speed-press Guard

FIG. 6 shows a 7½-ton high-speed press manufactured by the Norton Tool Co. Ltd. which has been fitted with a rigid Perspex guard and has been one of the principal features at a trade show recently held at Hammersmith Town Hall by Frank Lewis and Co. Ltd. of 65, St. Pauls Churchyard, London, E.C.3, who are the sole distributors. The press was described in detail in the March, 1960 issue of SHEET METAL INDUSTRIES but without the guard, which is claimed to have the effect of increasing production of the order of 100 per cent and more, with reduced fatigue on simple hand fed operation work.

The guard is hydraulically operated with the press circuit so that all pressure is relieved from the ram until the guard is in the fully closed position. When the press is set for single cycling, the action of closing the guard strokes the ram, the guard remaining self-locked in the closed position as the ram descends, and automatically opening as the ram returns. The weight of the guard and counterpoise arrangements are such as to make the guard light and rapid in operation.

A lever is provided to lock the guard in the closed position where necessary for manual operation of the press or fully automatic cycling. An isolator valve is also provided to allow the guard interlock to be rendered inoperative where necessary for purpose of tool setting and for operations in which guarding of the tool itself is more appropriate.

Fig. 6.—Automatic press guard



Non-destructive Testing Equipment

THE Introview flaw and corrosion detector illustrated in Fig. 7 was shown for the first time at the I.E.A. Exhibition by the manufacturers—Sperry Gyroscope Co. Ltd., Great West Road, Brentford, Middlesex. Up to now the detector has been used for the testing of non-ferrous material in tubular, strip or rod form, but recent developments have made it possible to use it on non-magnetic stainless steel.

The instrument makes use of the eddy currents set up in the material under test induced by an a.c. excited coil placed in close proximity to the material; these eddy currents modify the apparent impedance of the coil in proportion to the conductivity of the path created by the surrounding material; any variation in this conductivity causes a proportional variation in the apparent impedance of the coil, unbalances a bridge network and the magnitude and phase is recorded on a chart, thereby enabling flaws to be identified.

The equipment consists of a recorder unit, power pack, probe, probe injector and probe winch unit. In the illustration the equipment is being used inside the condenser box of a destroyer to test a condenser tube, the method being to propel a probe together with a flexible cable attaching it to the winch unit, to the far end of the tube by compressed air—the probe is then drawn back through the tube and a recording made of the state of the condenser tube on the recorder unit.

(*Continued in page 788*)

Fig. 7.—Flaw and corrosion detector being used to test condenser tubes

Electrical Aids in Industry *Data Sheet* **No. 12**

Dielectric Heating - 3

Some further details of the uses to which dielectric heating can be put are given in this data sheet, being continued from data sheet No. 11.

The Woodworking Industry

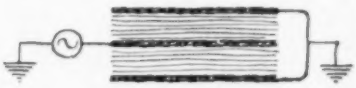
A most important development in recent years in the woodworking industry has been the introduction of synthetic resin adhesives of the thermosetting type for the bonding of wooden components. Setting of these resin adhesives proceeds at a rate largely determined by temperature. For instance, urea formaldehyde sets as follows :

TEMPERATURE	SETTING TIME
65°F	3 hours
80°F	1 hour
150°F	3 minutes
190°F	1 minute

The resultant bonded joint is equally satisfactory in each case. Most of the power supplied when dielectric heating is used is absorbed by the resin, the heat thus being concentrated where required.

Plywood

With dielectric heating consuming power only during the heating cycle, plywood can be produced with considerable savings in heating times and costs.



For example, in a press holding 100 3-ply ¼" thick assemblies, the resin glue is set in 20-30 minutes, depending upon the dryness of the wood.

Curved Laminated Sections

Curved laminated sections are being increasingly used in contemporary furniture, and with dielectric heating rapid production can be achieved using wooden shaping blocks in single daylight presses. An alternative method of providing heat by conduction from heated metal strips is much slower as the total section thickness rises above 0.05 inch.

Furniture Assembly

Because of the savings in glueing processes already instanced, dielectric heating is being extensively used in the furniture trade. It leads also to reductions in labour and floor space, with the elimination of assembly jigs. The heating equipment can be placed directly in the production line, cutting handling to a minimum.

Blockboard

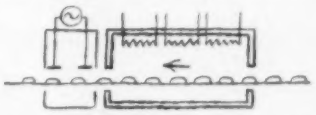
Blockboard, having large areas of glue line, provides an excellent use for dielectric heating, which gives considerable savings in time and labour.

Other Resin-bonded Products

Dielectric heating is also used in the manufacture of other resin-bonded or impregnated products such as grinding wheels, fabrics, felts, etc.

Foodstuffs

Increased use is being made of dielectric heating in many food processes; these include defreezing and melting, sterilisation and disinfestation, drying of breakfast cereals, dog biscuits, etc., and similar applications. Some cooking processes, such as bread baking, are technically possible, but dielectric heating gives an 'unbrowned' product. In the biscuit trade, however, dielectric heating is combined with conventional baking to produce normal biscuits in ½ to ½ the usual baking time.



The examples given here cover only a part of the field open to dielectric heating.

For further information, get in touch with your Electricity Board or write direct to the Electrical Development Association, 2 Savoy Hill, London, W.C.2. Telephone : TEMple Bar 9434.

Excellent reference books on electricity and productivity (8/6 each, or 9/- post free) are available—"Induction and Dielectric Heating" is an example.

E.D.A. also have available on free loan in the United Kingdom a series of films on the industrial uses of electricity. Ask for a catalogue.

7168/4

CET 8588

Lubricator for Self-levelling Greases

THE "SG" grease lubricator, Fig. 8, produced by Wakefield-Dick Industrial Oils Ltd., is a positive action lubricator designed specifically for the purpose of pumping self-levelling greases and is claimed to show a considerable first cost saving against all-purpose grease lubricators; it is compact and robust, has a grease capacity of 8 lb., and is fitted with up to 6 outlet connexions. The lubricator can be supplied with a plain drive shaft, or the drive can be arranged through a sprocket, pulley or ratchet; alternatively, it can be fitted with its own worm or ratchet reduction gearbox to take advantage of higher driving speeds. A complete installation, comprising the lubricator directly coupled to a fractional h.p. geared motor and mounted on a mild-steel baseplate can also be provided. Where non self-levelling greases are to be handled, the appropriate Wakefield-Dick lubricator is the "52G."

Further details of both lubricators can be obtained from the Mechanical Appliances Department, Wakefield-Dick Industrial Oils Ltd., Castrol House, Marylebone Road, London, N.W.1.

Fig. 8.—Self-levelling grease lubricator

Drill Grinding or Sharpening Machine

FIG. 9 shows the "Tatar" drill grinding machine for which Alfred Herbert Ltd. of Coventry are the sole agents, and which is claimed to simplify the concentric sharpening of even the smallest twist drill. A projector-adjustment permits a twist drill to be re-sharpened in approximately 10 seconds, centring the drill also taking only a few seconds.

Magnification on the projector system is from ×10 to ×60. After each pass across the grinding wheel, the drill is returned to a position in front of the viewing lens enabling a visual check to be made by the operator on the condition of the edge. By rotating the drill in its holder, the operator can also check the concentricity of the drill.

No centring device is required when mounting the drill in its collet and only one collet is necessary for drills from $\frac{1}{64}$-in. to $\frac{1}{32}$-in. Right- and left-hand drills can be accommodated and the machine is made in two sizes for drills from $\frac{1}{64}$-in. to $\frac{1}{32}$-in. and $\frac{1}{16}$-in. to $\frac{3}{64}$-in.

Lip angle is 90° to 140° and clearance angles 0° to 30°.

Fig. 9.—Drill grinding machine

Liquid Zinc Anti-Corrosive Compound

A LIQUID zinc anti-corrosive composition for use on iron, steel and other metal surfaces, has been developed by the MacCleaster Chemical Co. Ltd. (a Powell Duffryn Company), of 8, Great Tower Street, London, E.C.3.

The preparation has a base of chlorinated rubber and zinc dust of extremely small particle size, and among the important advantages claimed for it is freedom from rapid settling out. It can be applied by brush or spraying or by dipping, over rusted surfaces or surfaces which have been previously painted, subject only to some scraping or wire brushing. It is also of above average flexibility, abrasion resistant, and although not specifically heat resistant, will withstand a dry temperature of 200°C. and a wet temperature of 120°C. It possesses excellent fire retardant properties, prevents "rust creep," is impervious to polluted atmosphere (industrial fall out), to sea and fresh water. The manufacturers claim that the composition is equally efficient as a single coat system (as a primer, giving increased adhesive properties to the top decorative finish), making it particularly suitable in the protection of structural steelwork and for general industrial use. Its cathodic properties are especially important for marine application and since the dried film is non-toxic it can be used for the protection of water tanks and cisterns. It is now commercially available after an extensive period of field-testing.

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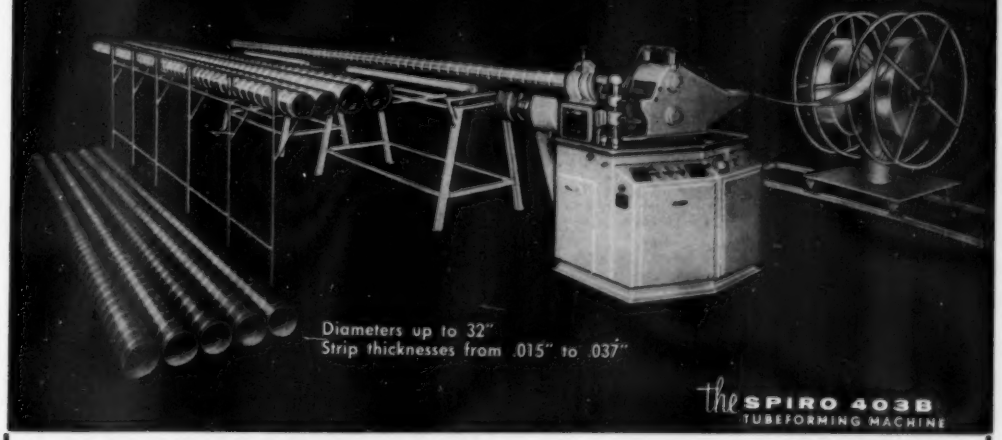

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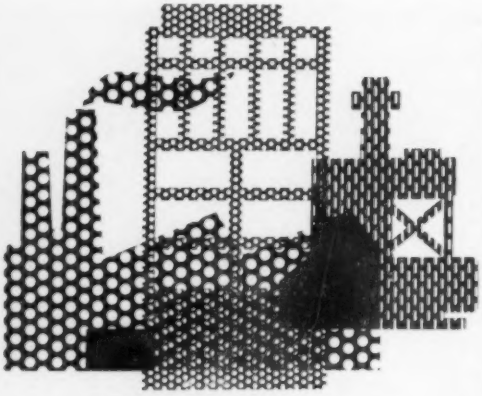

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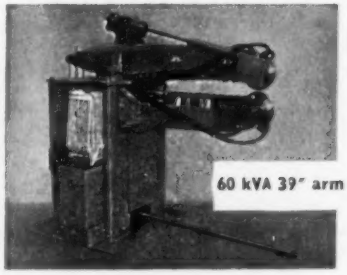

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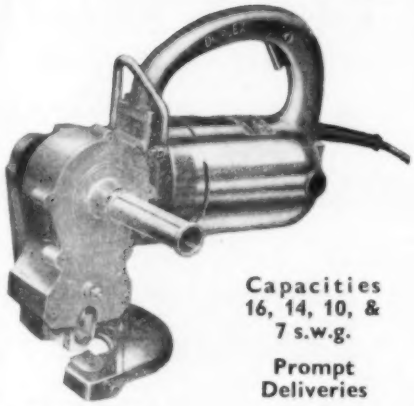

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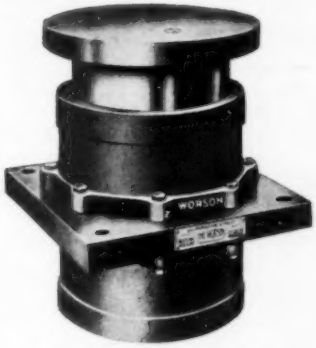

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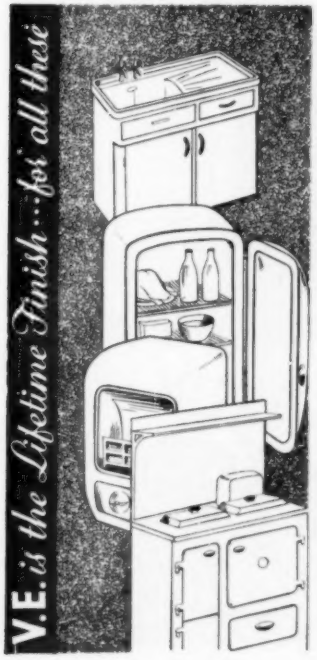

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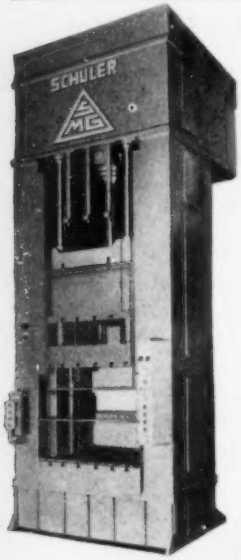

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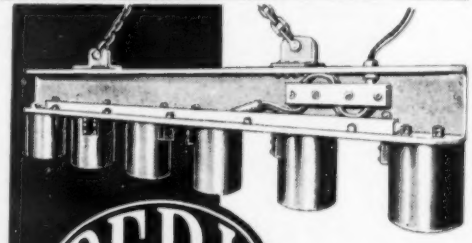

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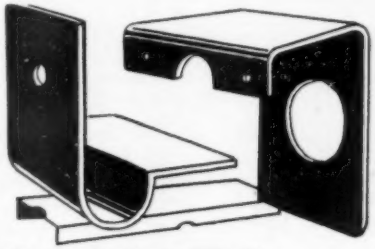

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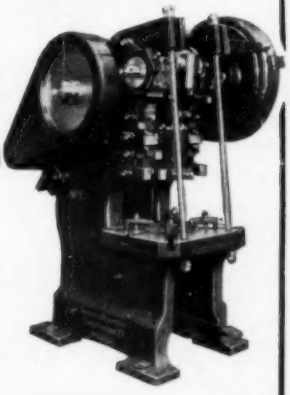

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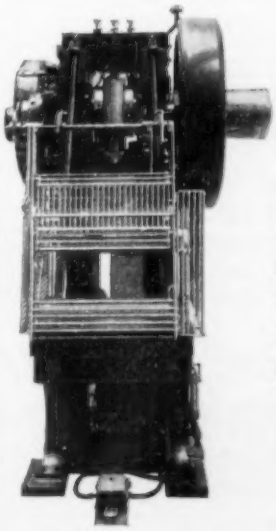

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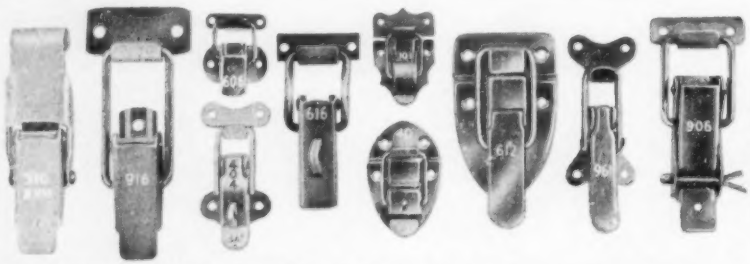

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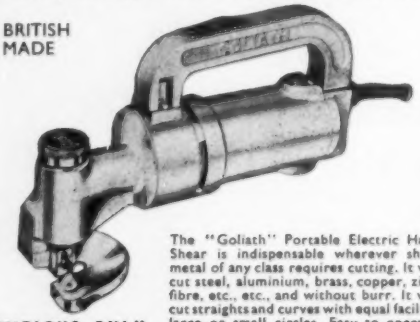

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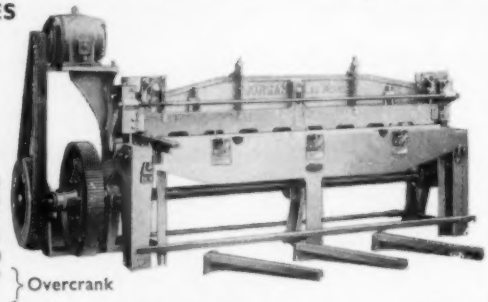

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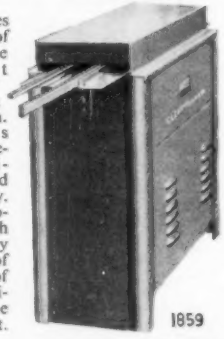

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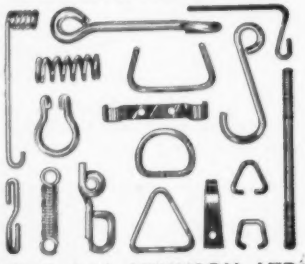

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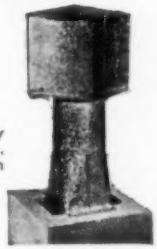

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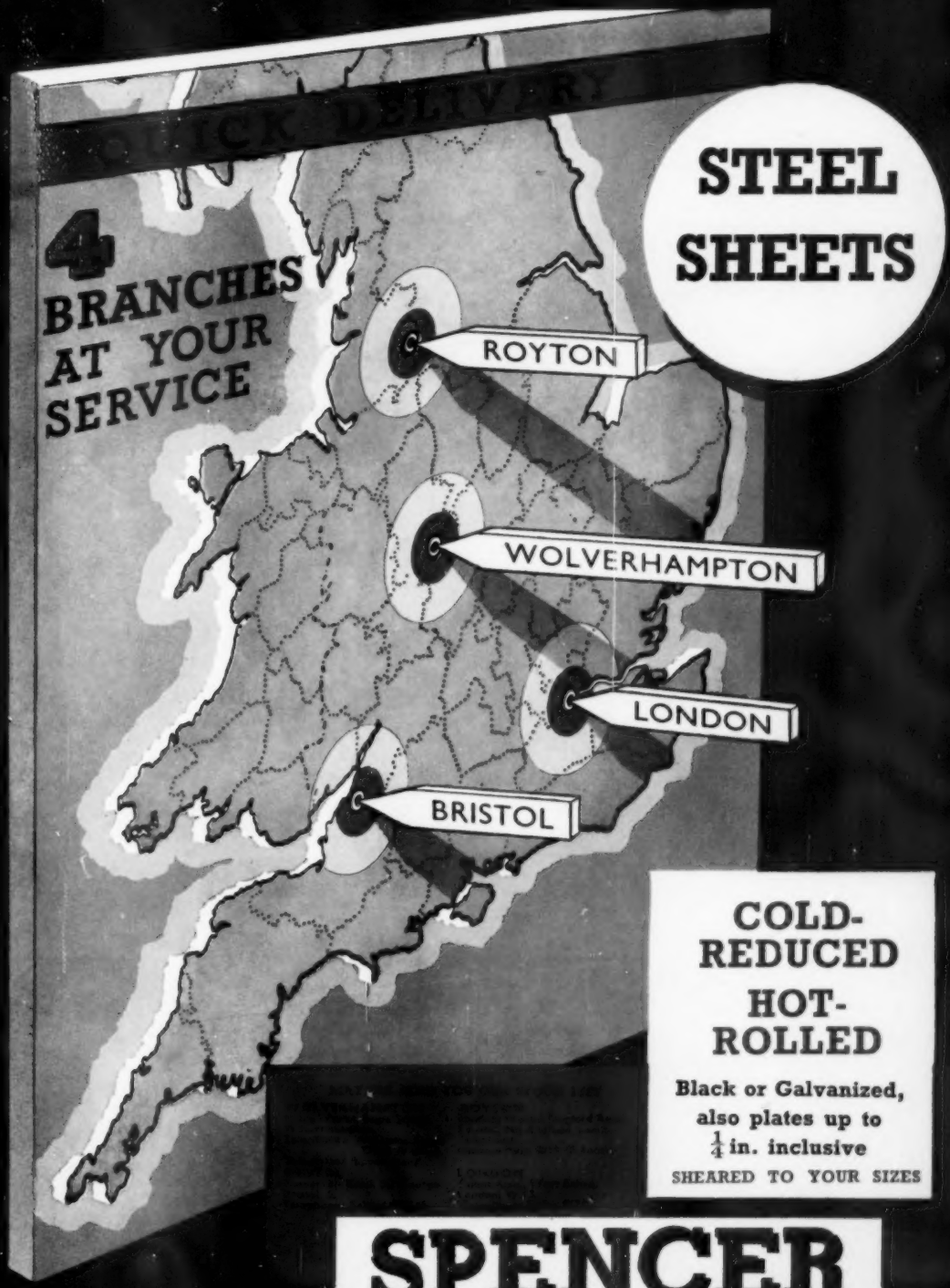
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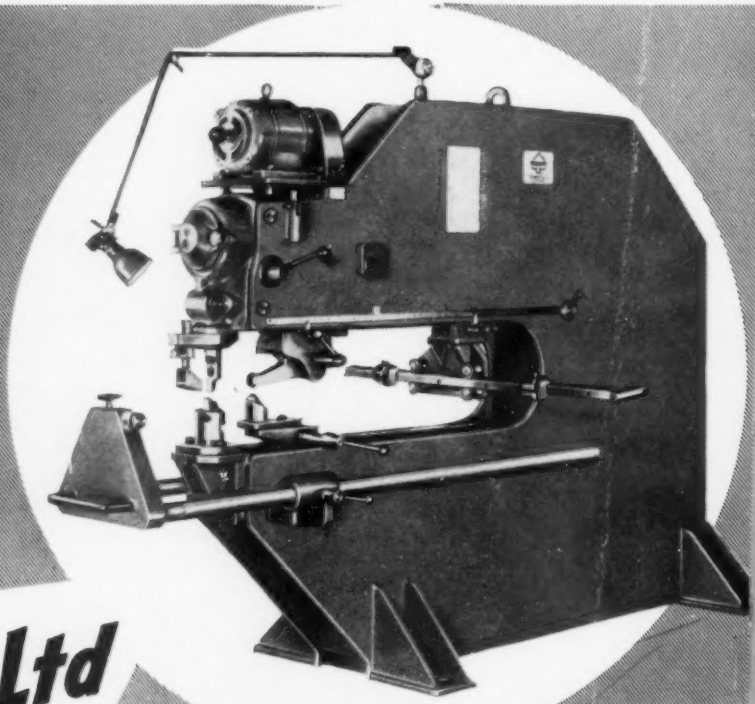

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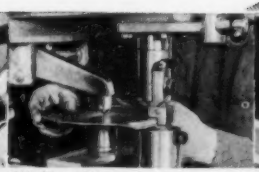
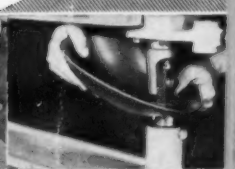


Working with the flanging tool and circle guiding attachment.



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